A STUDY OF THE EUROPEAN COMMUNITY IMPORT DEMAND FOR FRESH FRUITS AND FRESH GRAPEFRUIT: A DEMAND SYSTEM APPROACH

BY

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TO UDOM AND KEMARIN

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A STUDY OF THE EUROPEAN COMMUNITY IMPORT DEMAND FOR
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A modified Rotterdam/Working's model was used to investigate the factors affecting import demand for different fresh fruits and for fresh grapefruit from different suppliers in the European Community (EC) market. Under block independence, two import-demand systems were estimated, using seemingly unrelated regressions with Slutsky symmetry and adding-up restrictions imposed.

Results from the import-demand system for fresh grapefruit from different suppliers indicated that: (1) if the EC expenditures in imported grapefruit were increased by one percent, import demand for fresh grapefruit from the U.S., Israel-Cyprus, and the rest of the world in the northern hemisphere (ROWN) would increase by 3.0, 0.4, and 0.7 percent, respectively; (2) fresh grapefruit imports from the U.S. had unitary price elasticity, while those from Israel-Cyprus and ROWN were price inelastic; and (3) fresh grapefruit imports from the U.S. and Israel-Cyprus were substitutes for each other, while fresh grapefruit imports from the U.S. and ROWN were complements to imports from the rest of the

world in the southern hemisphere (ROWS). The findings from this study indicated that total import demand for fresh grapefruit in the EC is not likely to increase in the near future. However, the elasticity estimates showed that there is a possibility for fresh grapefruit from different suppliers to compete for market share in the EC.

Results from the system of equations for import demand for fresh fruits indicated that: (1) as import demand for fresh fruits as a group in the EC increases, the conditional import share for fresh oranges and other fresh citrus increases; (2) for a one-percent increase in import expenditures for fresh fruits, there would be 2.0-, 3.0-, and 0.5-percent increase in import demand for fresh oranges, other fresh citrus, and other fresh fruits, respectively; (3) the estimated elasticity of demand for fresh grapefruit with respect to total expenditure for fresh fruits is significantly not different from zero; and (4) all four groups of fresh fruits imported into the EC are negatively related to their own prices.

CHAPTER 1
INTRODUCTION

The U.S. is the world's leading producer of grapefruit products. Since 1975, production of grapefruit in the U.S. accounted for more than 50 percent of total world production (Table 1-1). Florida is the major production area in the U.S. From 1981 through 1987, Florida's share of U.S. grapefruit production increased from 65 to 79 percent; Florida grapefruit production accounted for more than 40 percent of total world production (Florida Agricultural Statistics Service 1989). Grapefruit production in Florida increased from 48.1 million boxes in the 1973-74 season to a record high of 54.8 million boxes in the 1979-80 season. This was prior to the freezes in the early 1980s. As a result of these freezes, Florida grapefruit production declined to 39.4 million boxes in the 1982-83 season but increased to 53.9 million boxes in the 1987-88 season (Table 1-2). During 1981-1987, the total production share of grapefruit in the U.S. and Israel, the two major producers of the world, declined from 62.8 and 11.5 percent to 54.3 and 9.0 percent, respectively (Table 1-1). Even though the U.S. share of world production of grapefruit has declined, production of grapefruit in Florida has increased in the past two decades. This study focuses on the import demand of fresh grapefruit in the European Community (EC). Accordingly, the production of grapefruit from other major suppliers for the EC also has to be investigated. In addition to the U.S. and Israel, there are three other major countries supplying fresh grapefruit to the EC; i.e., Cyprus, South

Table 1-1. Percent of World Production of Grapefruit in Five Major Exporting Countries to the European Community, 1975-87.

Year	U.S.	Israel	Cyprus	South Africa	Argentina
1975	62.77	11.53	1.00	2.29	5.11
1976	64.67	11.51	1.43	2.13	4.10
1977	62.07	11.21	1.49	2.53	3.84
1978	63.18	10.60	1.52	2.30	3.33
1979	60.31	12.06	1.71	2.58	3.23
1980	60.81	11.43	1.91	2.47	3.68
1981	56.25	11.10	2.00	2.56	3.37
1982	57.61	11.78	1.94	1.32	3.27
1983	55.14	11.43	2.14	1.81	3.65
1984	53.01	10.96	2.58	1.53	3.89
1985	53.69	9.84	1.36	1.57	4.12
1986	52.97	9.41	1.37	1.62	3.99
1987	54.31	9.00	1.52	2.57	3.74
Mean	58.21	10.91	1.69	2.10	4.04

Note: Including production of pomelos.

Source: FAO Production Year Book, 1975 through 1987.

Table 1-2. Florida Grapefruit Production by Variety, 1973-74 through 1987-88 Seasons.

Season	Colored Seedless	White Seedless	Seedy	Total
	---------- 1,000 boxes ----------			
1973-74	12,200	25,900	10,000	48,100
1974-75	11,500	25,900	7,200	44,600
1975-76	13,000	28,300	7,800	49,100
1976-77	12,500	29,900	9,100	51,500
1977-78	14,300	28,700	8,400	51,400
1978-79	13,300	29,400	7,300	50,000
1979-80	15,800	31,100	7,900	54,800
1980-81	14,600	28,400	7,300	50,300
1981-82	14,800	27,300	6,000	48,000
1982-83	12,800	21,800	4,800	39,400
1983-84	13,400	23,000	4,500	40,900
1984-85	16,300	24,800	2,900	44,000
1985-86	18,000	25,600	3,150	46,750
1986-87	20,000	26,900	2,900	49,800
1987-88	21,900	29,200	2,750	53,850

Source: Florida Agricultural Statistics Service, "Citrus Summary", 1989.

Africa, and Argentina. During the period from 1975 through 1987, production of grapefruit in Cyprus, South Africa, and Argentina, as a percent of world production, averaged 1.7, 2.1, and 4.0 percent, respectively (Table 1-1). Even though these shares are small, the export shares of Cyprus, South Africa and Argentina to Europe are relatively large compared to their domestic consumption.

Domestic production of grapefruit in the EC countries is relatively small compared to imports. In the 1970s, before Greece, Spain, and Portugal joined the EC, Italy was the only country producing grapefruit. The average production of grapefruit in Italy was 3,000 metric tons, which was less than 0.1 percent of total world production (FAO 1975-1987). After Greece, Spain, and Portugal joined the EC in the 1980s, production of grapefruit from these three countries and Italy increased to 35,000 metric tons. However, this production is still less than one percent of total world production (FAO 1975-1987). The following section focuses on production and utilization of grapefruit in Florida.

Production and Utilization of Grapefruit in Florida

The two major varieties of grapefruit grown in Florida are the colored (or pink) seedless and the white seedless grapefruit. In the 1973-74 season, these two varieties accounted for 80 percent of total production in Florida and increased to approximately 95 percent in the 1987-88 season (Florida Agricultural Statistics Service 1989). The markets and utilization of these two varieties of grapefruit differ. Colored grapefruit is mainly for domestic consumption and export to the EC as fresh product; however, Florida white seedless grapefruit products, both in fresh and juice forms, are mainly for export to Japan. In 1988,

more than 90 percent of the Florida white grapefruit export shipments were destined to Japan, and more than 90 percent of the colored grapefruit export shipments were destined to Europe and domestic markets (Florida Department of Citrus 1989a).

From the period 1980 to 1982, the production of all grapefruit in Florida declined by 28 percent as a result of freezes. In 1988, production of white seedless and seedy grapefruit were below the pre-freeze level by 6.1 and 65.2 percent, respectively; however, the production of colored seedless grapefruit exceeded the pre-freeze level by 38.6 percent (Florida Agricultural Statistics Service 1989).

Export Markets for U.S. Citrus Products

Export markets for food and agricultural products are a vital part of the U.S. world trade, with the export value of agricultural products totaling $39.7 billion at the end of fiscal year 1989 (U.S.D.A. 1989). This figure placed the total sales value as the highest since 1981, when total sales value was $43 billion. Major U.S. export products (from highest export value) are feed grains, wheat and flour, wood products, soybean and products, livestock products, and horticultural products. The export value for horticultural products as a group rose from $2.6 billion in 1984 to $4.2 billion in 1989 (U.S.D.A. 1989). Significant gains occurred in nearly all products falling within this category, notably in fresh and processed fruits and vegetables and in nursery products. Even though fresh fruit and vegetables account for a small part of the total exports of the nation, the gains in their export value are strong (i.e., increasing from $1.4 billion in 1988 to $1.5 billion in

1989). In addition, income from these export products is important to regional and state economies.

Citrus, one of the major agricultural commodities for the state of Florida, has become increasingly important in export markets. Table 1-3 indicates that the total free on board (F.O.B.) revenue from citrus-product exports from Florida increased by 78 percent, from $163 million in the 1985-86 season to $291 million in the 1987-88 season. During the same period, export revenue shares of total citrus exports for fresh oranges remained almost constant at 4.1 percent; processed oranges decreased from 33 percent to 29 percent; and export revenue shares for fresh grapefruit and processed grapefruit increased from 49 and 12 percent to 52 and 14 percent, respectively.

The discussion above indicates that export markets for Florida fresh grapefruit have been strong. The gains in export shares of Florida fresh grapefruit are primarily in the EC and Japanese markets. However, these two markets can be treated as different markets, since an average of 98 percent of Florida fresh grapefruit exported to Europe was colored (or pink) seedless grapefruit, while an average of 92 percent of total Florida fresh grapefruit exported to Japan was for white seedless grapefruit (Table 1-4). Table 1-5 shows that, from the 1978-79 through the 1984-85 seasons, total exports of Florida fresh grapefruit to the EC ranged between 3.0 and 3.9 million cartons[1] annually. Florida exports to the EC countries increased only after the 1984-85 season and reached 8.3 million cartons during the 1987-88 season. Florida fresh grapefruit exports to Japan increased from 7.1 million cartons in 1978-79 to 10.9 million

[1]One carton equals to 0.8 bushel.

Table 1-3. Export Values of Florida Fresh and Processed Citrus Products.

Product	Season		
	1985-86	1986-87	1987-88
	---------- million dollars ----------		
Fresh			
Grapefruit	80.39 (49.31)[a]	111.26 (53.52)	151.09 (51.97)
Round Oranges & Temples	6.74 (4.13)	8.08 (3.88)	11.82 (4.06)
Specialty	2.34 (1.44)	2.49 (1.20)	3.87 (1.33)
Processed Orange			
Frozen concentrate orange juice	48.09 (29.50)	52.64 (25.32)	74.62 (25.66)
Chilled orange juice	3.04 (1.86)	3.81 (1.83)	5.96 (2.05)
Canned single-strength orange juice	3.42 (2.10)	2.39 (1.65)	3.81 (1.31)
Processed Grapefruit			
Frozen concentrated grapefruit juice	17.04 (10.45)	25.45 (12.24)	36.99 (12.72)
Canned single-strength grapefruit juice	1.97 (1.21)	1.76 (0.85)	2.58 (0.89)
Total	163.03	207.88	290.74

[a] Numbers in parentheses are export revenue shares.

Note: Includes Canada.

Source: Florida Department of Citrus 1989a.

Table 1-4. Exports of Florida Fresh Grapefruit by Major Importing Countries and Varieties, 1978-79 through 1987-88 Seasons.

Season[a]	Europe		Japan		Canada	
	White	Pink	White	Pink	White	Pink
	1,000 cartons					
1978-79	136	3,226	6,360	723	1,526	1,473
1979-80	59	3,846	5,392	562	1,521	1,661
1980-81	85	3,579	5,843	595	1,299	1,468
1981-82	51	3,016	6,393	435	1,282	1,558
1982-83	134	2,899	6,054	413	1,357	1,506
1983-84	80	3,441	5,836	284	1,125	1,485
1984-85	58	3,033	2,331	228	1,039	1,607
1985-86	105	4,738	5,653	537	1,039	2,105
1986-87	121	6,112	7,923	996	856	2,084
1987-88	157	8,278	10,388	548	730	2,461
Average	99	4,217	6,217	532	1,177	1,741
Average share	2.29	97.71	92.12	7.88	40.34	59.66

[a] Seasons are from July 1 through June 30 for 1978-79 through 1983-84, and from August 1 through July 31 for 1984-85 through 1987-88.

Source: Florida Department of Citrus 1988.

Table 1-5. Total Exports of Florida Fresh Grapefruit by Country of Destination, 1978-79 through 1987-88 Seasons.

Season[a]	The EC	Japan	Canada	Others	Total[b]
	---------- thousand of 4/5 bushel cartons ----------				
1978-79	3,297	7,083	2,999	143	13,522
1979-80	3,862	5,954	3,182	133	13,132
1980-81	3,644	6,438	2,767	157	13,005
1981-82	3,022	6,828	2,840	83	12,772
1982-83	3,019	6,467	2,863	59	12,406
1983-84	3,473	6,120	2,609	102	12,303
1984-85	3,050	2,559	2,646	48	8,303
1985-86	4,752	6,190	3,144	137	14,223
1986-87	6,150	8,919	2,940	405	18,412
1987-88	8,266	10,936	3,191	1,466	23,859
Average	4,254	6,749	2,918	273	14,194

[a] Seasons are from July 1 through June 30 for 1978-79 through 1983-84 and are from August 1 through July 31 for 1984-85 through 1987-88.

Source: Florida Department of Citrus 1988.

cartons in 1987-88. Despite an increase in total quantity exported to both markets, the export share of total fresh grapefruit to the EC increased by 10 percent from 24 to 34 percent, while the export share for Japan decreased by six percent from 52 to 46 percent (Florida Department of Citrus 1989a).

The export share for the EC is expected to increase further in the future. Shipments of fresh grapefruit to France and the Netherlands increased significantly for the EC countries. The combined sales to these two countries accounted for 80 percent of total sales to the EC (U.S. Department of Agriculture 1980-88). However, the Netherlands is probably a transshipment point for the other EC countries (Eurostat 1987). The contribution to these increased exports may be due partially to the Florida Department of Citrus (FDOC) promotional activities sponsored by the U.S.D.A. Targeted Export Assistance (TEA) program. Details on these programs will be discussed later in this chapter.

Table 1-6 shows that from 1978 through 1988, total exports of U.S. grapefruit juice increased from 13.8 to 25.3 million single-strength-equivalent (SSE) gallons, an 84-percent increase. During this same period, U.S. export shares of total grapefruit-juice exports to Canada declined from 7.3 to 3.0 million SSE gallons, whereas U.S. export shares to Japan increased more than ninefold, from 1.3 million SSE gallons in 1978 to 11.6 million SSE gallons in 1987. This increase made Japan the largest importing country for U.S. grapefruit juice. U.S. grapefruit-juice exports to the EC countries fluctuated between 1.69 and 5.39 million SSE gallons from 1978 to 1988.

Given the changes in export markets and the allocation between export and domestic shipments of citrus products stated above, it is

Table 1-6. Exports of U.S. Grapefruit Juice by Country of Destination, 1978-88.

Year	The EC	Japan	Canada	Others	Total
	---------- 1,000 SSE gallons ----------				
1978	3,352	1,270	7,319	1,806	13,747
1979	5,231	1,955	7,024	2,371	16,581
1980	5,893	2,507	6,870	3,078	18,348
1981	4,545	5,151	7,340	2,866	19,902
1982	6,168	3,566	5,544	2,444	17,722
1983	3,620	3,854	4,090	2,796	14,360
1984	4,517	4,418	4,008	2,585	15,528
1985	1,698	6,120	3,541	2,129	13,488
1986	1,686	6,881	2,188	2,095	12,850
1987	2,106	9,272	3,916	1,713	17,007
1988	5,390	11,548	3,018	5,331	25,287
Average	4,019	5,140	4,987	2,656	16,802

Source: U.S. Department of Commerce 1978 through 1988.

important for the Florida's citrus industry to understand the demand for citrus products and to identify which products and regions have the most potential for future expansion of citrus exports. One important factor that needs to be considered in order to find potential export markets for these citrus products is the allocation between export and domestic markets. Data from Table 1-7 indicate that the domestic market is the largest market for both Florida fresh grapefruit and grapefruit juice. However, the growth rates of consumption of fresh grapefruit and grapefruit juice in the domestic market have declined during the past decade. Table 1-7 shows that, from 1978-79 through 1987-88, domestic shipments of fresh grapefruit decreased from 24.3 to 21.3 million cartons, and domestic shipments of grapefruit juice decreased from 104.3 to 72.0 million SSE gallons. Therefore, export markets have become relatively more important to the U.S. grapefruit industry. From the 1978-79 to 1987-88 seasons, total export shipments of fresh grapefruit increased from 13.6 to 23.9 million cartons, or from 35.9 to 52.8 percent of total shipments. Export shipments of grapefruit juice also increased from 16.6 to 25.3 million SSE gallons, or from 13.7 to 26.0 percent of total shipments.

The three major exporting regions for U.S. grapefruit products are Japan, Canada, and the EC countries. Demand for grapefruit products in Japan is primarily for the white variety, whereas the preference for white grapefruit in the U.S. and Canada has declined over the past decade. This, in turn, has freed up the supply of white grapefruit products, so that the U.S. could respond to the increased demand from Japan (Florida Department of Citrus 1989b). The EC, Canada and Japan are the regions with the most potential for future expansion of Florida fresh grapefruit export. From 1978 through 1988, exports of Florida fresh grapefruit to

Table 1-7. Domestic and Export Shipments of Florida Fresh Grapefruit and Grapefruit Juice, 1978-79 through 1987-88 Seasons.

Season	Fresh Grapefruit[a]			Grapefruit Juice		
	Domestic	Export	Total	Domestic[b]	Export[c]	Total
	--- million cartons ---			--- million SSE gallons ---		
1978-79	24.30 (64.15)	13.58 (35.85)	37.88	104.3 (86.27)	16.6 (13.73)	120.9
1979-80	23.38 (64.04)	13.13 (35.96)	36.52	96.6 (84.07)	18.3 (15.93)	114.9
1980-81	19.32 (59.77)	13.01 (40.23)	32.32	91.5 (82.14)	19.9 (17.86)	111.4
1981-82	18.89 (59.66)	12.77 (40.34)	31.66	90.7 (83.67)	17.7 (16.33)	108.4
1982-83	22.21 (64.16)	12.41 (35.84)	34.62	89.6 (86.40)	14.1 (13.60)	103.7
1983-84	18.24 (59.71)	12.30 (40.29)	30.54	81.5 (84.02)	15.5 (15.98)	97.0
1984-85	21.33 (71.98)	8.30 (28.02)	29.63	90.6 (87.03)	13.5 (12.97)	104.1
1985-86	24.47 (63.24)	14.22 (36.76)	38.69	85.0 (86.91)	12.8 (13.09)	97.8
1986-87	22.76 (55.28)	18.41 (44.72)	41.18	78.2 (82.14)	17.0 (17.86)	95.2
1987-88	21.34 (47.21)	23.86 (52.79)	45.20	72.0 (74.0)	25.29 (26.0)	97.29

Note: Numbers in parentheses are domestic and export shares.

Sources: [a] Florida Department of Citrus 1988.
[b] A.C. Nielsen Company 1978 through 1988.
[c] U.S. Department of Commerce 1975 through 1988 .

the EC, Japan, and Canada increased by 150, 54 and six percent, respectively (Florida Department of Citrus 1988). The discussion above indicates that the region with the fastest expansion rate of Florida fresh grapefruit exports is the EC countries. This study will investigate the import demand for fresh grapefruit in the EC market.

Problem Statement

The EC market is considered to be the world's largest importer of fruit and vegetable products. In the past decade, the EC absorbed about 50 percent of total world exports of both fresh and processed fruit (Sarris 1984). In 1989, the European market was the second largest market for U.S. agricultural exports, the first being Japan (U.S. Department of Agriculture 1989).

The U.S. has been developing export markets for its citrus products in the European Community (EC) since the 1960's. One method used to expand markets for citrus products in Europe is the cooperative market development and brand advertising program, or the Cooperator's program. This program was initiated in 1967 and is jointly supported by the Florida Department of Citrus (FDOC), the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture, and foreign distributors. The Cooperator's program is primarily designed for maintenance and market development in the European countries by supporting brand promotion activities of distributors of fresh and processed citrus products. These activities range from advertising and promotional programs to public relations. However, it has been used mainly to promote orange juice and fresh grapefruit (Fairchild 1983).

Another method used to expand the market for citrus products in the EC is the Targeted Export Assistance (TEA) program. The TEA program, along with the Export Enhancement Program (EEP), was carried out as part of the 1985 Food Security Act to counter unfair foreign trade practices. The 1985 Food Security Act was put into effect on December 23, 1985, in order to recapture the shrinking U.S. share of world markets for agricultural products in the 1980s. However, much of the shrinking U.S. share in world markets was probably due to an increase in competition of the EC in world commodity markets, especially for grain. In addition, several of the traditional grain-importing countries, such as China and India, became net exporters in the early 1980's.

Following the 1985 Food Security Act, several farm programs have been carried out. These programs were designed to cover most of the important export farm products. For example, one of the commodities covered in the TEA program is citrus. The TEA funds designated for the Florida citrus industry increased from $5.1 million in the 1987 fiscal year to $6.5 million in the 1988 fiscal year (Florida Department of Citrus 1989a). The bulk of this fund was used to promote fresh grapefruit in Western Europe. Therefore, an increase in Florida supply, combined with the effort of the TEA program, is likely to keep export markets in the EC strong.

One of Florida's most promising citrus exports to the EC countries is fresh grapefruit (U.S.D.A. 1988). During the winter months, the U.S., Israel, and Cyprus are the three major suppliers of grapefruit products to the EC; South Africa and Argentina are the major suppliers during the summer months. Over the years 1978 to 1987, the U.S., Israel, and Cyprus

supplied approximately 66 to 74 percent of total fresh grapefruit imports to the EC (Eurostat 1980-87). During the same period, market shares for U.S. fresh grapefruit in the EC increased from 21 to 29 percent; likewise, the market shares for Israel and Cyprus, the major competitive sources of fresh grapefruit in the EC, decreased from 53 to 40 percent (Eurostat 1980-87). Market shares of fresh grapefruit for South Africa and Argentina in the EC remained relatively stable at 20 percent. One of the factors that will be considered in import demand for fresh grapefruit in the EC is relative prices. On average, the import price of fresh grapefruit from the U.S. has always been higher than those from other sources of supply by 12 to 32 percent (Table 1-8). Regardless of this higher price, the expenditure share for U.S. fresh grapefruit in the EC has been increasing. Therefore, it is crucial to understand the changes in the EC's grapefruit market and to study the trade flow and future trends of import demand of fresh grapefruit in the EC countries.

Objectives of Study

The Florida citrus industry has actively pursued policies to increase the competitiveness of its grapefruit products in the EC markets. As a result, an empirical analysis of EC import demand for these products is essential. The overall objective of this research is to provide such an empirical analysis of import demand for fresh grapefruit in the EC countries.

The specific objectives of this study are as follows:

(1) to develop a theoretical import-demand model for fresh fruits and fresh grapefruit in the EC countries based on international trade theory;

Table 1-8. European Community Import Prices of Fresh Grapefruit from Four Different Groups of Suppliers, 1975-87.

Year	Supplier Country			
	U. S.	Israel-Cyprus	ROWN[a]	ROWS[b]
	ECU per Kg.			
1975	.28436	.19987	.26726	.28988
1976	.31570	.21706	.24172	.30051
1977	.30900	.22851	.50041	.27067
1978	.30204	.25494	.27744	.32757
1979	.39274	.28839	.27741	.37976
1980	.41026	.30692	.35652	.43382
1981	.51161	.32755	.40168	.44541
1982	.57526	.34218	.41765	.49437
1983	.58616	.36715	.53446	.50111
1984	.66610	.39959	.53893	.54598
1985	.83463	.54735	.61363	.64868
1986	.64501	.48633	.52448	.52984
1987	.57781	.41841	.47110	.47332
Mean	.51053	.34870	.43795	.44592

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.

Source: Eurostat 1975 through 1987.

(2) to investigate factors affecting the import demand for fresh fruits in the EC markets;

(3) to investigate the factors affecting the import demand for fresh grapefruit in the EC markets; and

(4) to analyze the implications from the estimated import-demand model and provide information to help formulate long-run trade strategies for U.S. fresh grapefruit exports to the EC.

Organization of the Study

The organization of this study is divided into six chapters. Chapter 2 is a review of the literature. The first section of this chapter presents the factors affecting trade. A brief discussion on development of the EC and its trade policy is provided in the second section. The third section contains empirical models used in international trade. Finally, the fourth section provides a review of past studies on trade of grapefruit products in the European countries. In the third chapter, methodology and development of theoretical models will be presented and discussed. Chapter 4 builds on the Rotterdam and Working's models. Both an unconditional and a conditional version of Working's model are presented. Further, a modified Rotterdam/Working's model is derived via parameterizing the general form of the differential demand equation. Chapter 5 explains the data sources and aggregation process used in this study. Empirical results of an import-demand subsystem for fresh grapefruit and an import-demand system for fresh fruits in the EC will be presented and discussed. Finally, a summary and implications for future research will be provided in Chapter 6.

CHAPTER 2
REVIEW OF LITERATURE

This chapter consists of four sections. The first provides an overview of factors affecting trade. The second deals with the development of the European Community and its trade policies. In the third section, the selection of recent empirical models and different approaches used in international trade are reviewed and briefly summarized. Finally, past studies on trade of grapefruit products in the European Community will be presented and discussed in the fourth section.

Factors Affecting Trade

International trade in agricultural products has become increasingly important. The fundamental reason for international trade is that trading countries can obtain the benefits of specialization. Nations, like individuals, are not equally suited to produce all goods, because they are either differently endowed or for other reasons. All would benefit if each concentrated on the production of the goods in which it has a comparative advantage and obtained the other products through trade (Kreinin 1979).

Recently, there has been an increased level of international trade due to the improvement and convenience of transportation. This, however, creates a more competitive environment, with each trading country trying to find a way to protect its industries. Protection methods are usually based on both economic and political arguments. It is important to

understand some of the protection instruments and their distortions of trade patterns.

The theory of international trade states that the best policy, from the world point of view, is for every country to have free trade. However, in reality one sees some forms of barrier to free trade. The most common reason for trade barriers is to protect domestic industries. Barriers to trade are sometimes set up for other reasons. For example, an import tariff can be used to create revenue for the government.

Traditionally, tariffs have been the most common instrument of protection. A tariff is a tax levied upon a commodity when it crosses a national boundary. Tariffs can be in the form of either import duties or export taxes. Even though tariffs are the most widely used instruments of protection, they are not the only ones. Non-tariff barriers, such as import quotas and voluntary export restraints (VER), are also important and should be taken into consideration. The import quota restricts the volume of imported products and is set by the importing country's government. These limits are presumably below what would be imported under free trade. Quotas were common in Western Europe immediately after World War II (Kreinin 1979). The similarity in tariffs and import quotas is that both instruments result in raising the domestic price of the imported good and thereby protect the domestic industries. However, a major difference is that, by imposing a tariff, the government can collect revenue; while, with a quota, the government does not necessarily receive revenue. However, quota rents exist; and who will receive this rent depends on how the import licenses are issued (Krugman and Obstfeld 1987).

Another device that has been widely used recently is called the "Voluntary Export Restraint" (VER). Under the VER, the exporting country

agrees to impose a quota on the export of goods to the importing country. The advantage of a VER over import quotas and tariffs is that VERs give the same protection without violating the spirit of the GATT. Recently, VERs have been an effective method of protection in international trade. However, it is most often used in the trade of manufactured products rather than in the trade of agricultural products. An exception is for meats from Australia and New Zealand imported into the U.S.

In most of the industrial and developed countries, including the EC and the U.S., agricultural sectors are often protected because the farmers are politically powerful (Kreinin 1979). Government interventions are usually in the forms of price supports, import taxes or export subsidies.

Development of the European Community and Its Trade Policy

The European Economic Community (EEC) is the regional organization of industrial West European nations. It was established in 1957 by six Western European nations: West Germany, France, Italy, Belgium, the Netherlands, and Luxembourg. The establishment of the EEC was perhaps the most significant development in international trade matters after World War II. The goal of the EEC-6 was to achieve political integration by using economic union as a vehicle to attain that goal. In 1977, the United Kingdom, Ireland, and Denmark joined the EEC, which increased the membership to nine countries. The official name of the EEC had also been changed to the European Community (EC), since it encompasses the European Economic Community, the European Coal and Steel Community, and Euratom (Kreinin 1979). The second enlargement of the EC-9 to the EC-12 was in the 1980s, when Greece, Spain, and Portugal became members.

Despite other functions, the major concern of the EC is its effects on trade policy. First, the European communities operate in the form of a custom union. Member countries of the EC removed all tariffs and other trade restrictions with respect to each other and set up a common and uniform tariff against outsiders (e.g., the tariff for imported fresh grapefruit is three percent; that of oranges and other fresh citrus range from four to 20 percent). However, there are some exceptions, such as preferential tariff treatment, where the EC provides such treatment for Mediterranean suppliers of fresh and processed citrus products.

The second effect on trade of the EC countries is the implementation of the Common Agricultural Policy (CAP). This policy consists of free trade within the community, support prices for many products, and highly restrictive import policies to maintain internal prices. Initially, the CAP program was intended to guarantee high prices to European farmers by setting tariffs that offset the difference between European and world agricultural prices. It was intended to encourage self-sufficiency in the EC agricultural sector and to lower net import requirements. However, this program later created large surpluses of EC agricultural products. In order to resolve this problem, the EC established an export subsidy program to help dispose of these surpluses (Krugman and Obstfeld 1987).

The export subsidy program in the EC countries has become so large that the costs of this program to consumers and taxpayers exceed the benefits to producers (Krugman and Obstfeld 1987). Since agricultural sectors in the EC, like other industrial nations, are powerful politically, trade policies are often established for political reasons and not just economic ones. Even though protectionism in the EC is mainly for grain and dairy products, the fruit and vegetable industries are also

protected by the imposition of variable levies on imported fruits and vegetables.

Empirical Models Used in International Trade

In 1981, Thompson conducted a survey of recent U.S. developments in international agricultural trade models for both two-region and multiple-region models. The two-region models divided all countries of the world into two groups, the country of interest and the rest of the world. Two-region models are basically domestic agricultural sector models that are open to international trade. Since these models do not account for trade flows but explain only net trade between the country of interest and the rest of the world, they are not trade models in the strictest sense. Thompson concluded from his survey that the two-region models have achieved only limited success in contributing to the objectives of agricultural trade modeling. However, a model that is well specified and estimates export-demand and import-supply equations for important traded commodities may be adequate for analyzing the effects of changes in domestic farm policy or U.S. trade policy.

Multiple-region models of agricultural trade emphasize interrelations or simultaneities among countries through world trade. There are three basic classes of these models: nonspatial price-equilibrium models, spatial price-equilibrium models, and trade-flow or market-share models.

Nonspatial price-equilibrium models are comprised of systems of equations that can be solved by matrix inversion, if linear, or by an iterative procedure if nonlinear. These models explicitly treat the interrelations among trading regions, by assuming that the world market price is determined simultaneously by the supply-demand balance in all

trading regions such that the global market clears. Nonspatial price-equilibrium models make an important improvement over two-region models by endogenously determining the supply and disappearance in each of the trading regions in the model. The most important contribution of nonspatial price-equilibrium models to trade theory has been in analyzing the extent to which world market price shocks are transmitted into domestic markets, through policy-reaction functions or price-transmission equations. However, these models also have a disadvantage, in that they often link prices together in a manner which is not consistent with spatial price equilibrium. The models provide no information on trade flows or market shares. Moreover, most of them are partial equilibrium models that treat only one commodity in isolation from all others. This omission of relevant variables can cause biased parameter estimates and lead to erroneous predictions of changes in policy.

The second approach for multiple-region models is to use a spatial equilibrium modeling approach. Spatial equilibrium models endogenize trade flows and market shares. They are structured in a manner consistent with spatial equilibrium theory, such that prices are directly linked only between those pairs of countries that actually trade with each other. Spatial equilibrium models treat commodities as perfectly homogeneous. However, in the real world, commodities are not perfectly homogeneous in terms of physical characteristics. Even though these models have advantages over nonspatial equilibrium models (e.g., they generate trade flows and market shares), the capability of explaining real world trade flows by these models is still questionable. Dean and Collins (1967) and Zusman et al. (1969) analyzed the effects of the EC tariff and referenced price policies on world trade in fresh oranges using a spatial equilibrium

trade model. They used an iterative market-simulating procedure to approximate a spatial equilibrium solution. Additionally, in their studies, production and distortions came about only through governmental policies.

The third approach for multiple-region models utilizes trade-flow and market-share models. The development and applications of trade-flow and market-share models have been the frontier of agricultural trade modeling techniques. This approach takes into account that products are differentiated by origin and that they are not perfect substitutes. Trade-flow and market-share models can explain trade flows much more adequately than spatial equilibrium models. Some techniques, like the Armington approach (Armington 1969) and its extensions, offer considerable potential for improving trade-flow forecasting and policy analysis. The modified shares approach was used by Sarris (1983) to project changes in the world trade of fruits and vegetables with the enlargement of the EC-9 to the EC-12. This approach was shown by Armington to be a valid method of trade projection, when considering demand as distinguished by place of production.

A more recent approach in international trade tries to incorporate more than one commodity in an analysis. For example, allocation models developed by Theil (1980b) based on demand theory can also be used as import-allocation models in international trade. Some of the earlier works using allocation models to estimate a country's total imports from various exporting countries were conducted by Armington (1969); Barten (1971); Barten et al. (1976); Hickman (1973); and Hickman and Lau (1973). These studies used time-series data of world trade matrices. One of the studies, based on imports of one particular country, was done by Berner

(1975). His study assumed a two-stage budget; that is, a country firstly allocates the total expenditure for imports among all imported goods and secondly allocates the given budget from the first stage on demand for a particular group of goods over varieties supplied by different countries.

Two major allocation models applied in international trade are import-allocation models and total-allocation models (Italianer 1986). The import-allocation model is called the "structural approach" by Rhomberg (1970), the "share approach" by Waelbroeck (1973) and the "trade-allocation model" by Ranuzzi (1981). In import-allocation models, the total imports are determined in the first stage, and the bilateral imports should add up to this given total. In total-allocation models, total imports may simply be determined as the sum of bilateral imports from all trading partners. Recently, the import-allocation model has become more popular in empirical study (Italianer 1986).

Barten (1971) proposed a partition in the context of aggregate trade. He made a distinction between products produced domestically and abroad. This kind of partition is the true theoretical basis for the import-allocation model. Armington's partition, however, leads in principle to a total-allocation model and introduces the notion of a product distinguished by place of production. In the usual derivation of import-allocation models, Barten's contribution is normally neglected and reference is only made to Armington (Italianer 1986).

Clements and Theil (1978) applied the differential approach to production theory in the analysis of world trade. They used trade matrices of 1971 and 1975 to estimate demand for three imported product groups: food, raw materials, and manufactured goods from 13 countries. They estimated the price elasticity of demand under the assumption of

preference independence and unitary conditional Divisia elasticities of inputs of the same product bought from different countries.

Theil and Clements (1978) also applied the differential approach to production theory, using U.S. import data for four groups of goods: food, crude materials, semi-manufactures, and finished manufactures for the years 1921 through 1970. They assumed that imports as a group are weakly separable from other inputs; and then imports within a specific group are strongly separable. This is the same as the assumption of two-stage budgeting (Deaton and Muellbauer 1980). Theil and Clements (1978) estimated Divisia and price elasticities from this time series of U.S. imports of these four groups of goods without imposing restrictions on the Divisia elasticities.

Empirical Results on Trade of Grapefruit Products in the European Countries

Most of the current literature on trade in agriculture focuses on grain products. International trade in fresh and processed fruit products occupies only a minor part of the agricultural economic literature. One of the first studies of consumer demand for processed citrus in Europe was the 1969 study by Priscott. Priscott used least-squares regression to estimate import demand for Florida grapefruit juice and orange juice in the European market at the wholesale level. He used yearly data from the years 1952 through 1967 and monthly data from 1961 through 1968. His results showed that the estimated price and income elasticities were elastic, indicating that the European market had a potential to be successfully developed for citrus products.

Tang (1977) estimated the demand functions for fresh U.S. grapefruit in the U.S., Canada, Japan, and the EC by using quarterly data from 1971

to 1975. The analysis utilized both ordinary least squares (OLS) and seemingly unrelated regressions (SUR). Tang's results indicated that the demand for fresh U.S. grapefruit was price elastic in the Canadian and Japanese markets and inelastic in the U.S. and the EC. His results indicated that growth in grapefruit demand would occur in all four markets over time. Tang also found that fresh U.S. grapefruit and those of Israel were substitutes in the EC market.

In 1976, Shafer analyzed the fresh market for Texas grapefruit using annual data from 1960-61 through 1974-75 and weekly data from 1968-69 through 1975-76. He used ordinary-least-squares (OLS) regression to estimate linear equations. Shafer found that Texas fresh exports plus Florida fresh exports of grapefruit had positive relationships with Texas FOB prices for fresh grapefruit, while domestic use of fresh grapefruit from both states had a negative relationship with Texas FOB prices.

As mentioned earlier, one of the U.S. marketing strategies for expanding the European market for citrus products was the Cooperator's program started in 1967. The effectiveness of this program was measured by Lee et al. (1979). The period studied was fiscal years 1972-73 through 1976-77. Ordinary-least-squares (OLS) regression was used to estimate the parameters for a double-log model. Their results indicated that the program expenditures have generated additional dollar sales to Europe far in excess of the program costs. Moreover, the program was shown to be two to four times less costly than price discounting as a means of developing and maintaining European markets.

Balassa (1967) estimated the effects of trade creation and trade diversion associated with the establishment of the European Community. Balassa estimated the income elasticities of import demand for several

disaggregated commodity groups, including temperate-zone foods, beverages and tobacco, raw materials, fuels, chemicals, machinery, transport equipment, and other manufactured goods. His results showed that the net effect of the establishment of the EC was one of trade creation. The effect of the community on individual suppliers was found to vary, depending upon the commodity composition of their exports to the community. Balassa's study, however, did not cover the changes in relative prices.

Given that the EC-9, considered as a single entity, was the world's most important market for fruit and vegetable products, the second enlargement of the EC countries (from the EC-9 to the EC-12 by including Greece, Spain, and Portugal in the 1980's) was expected to have some effect on world trade patterns in this region. Recent studies by Sarris (1983, 1984) showed that the second enlargement of the EC countries will not significantly change the general pattern of world trade in fruits and vegetables, but will lead to larger exports to the EC by the three new member countries. Sarris developed a world trade model, based on Armington's model (1969), that differentiated products according to their country of origin. This model was used to project future trade patterns and terms of trade for five categories of Mediterranean products: fresh fruit, dried fruit, processed fruit, fresh vegetables, and processed vegetables. Sarris concluded that world trade patterns for fruits and vegetables, as represented by export and import shares, will not change much in the next three to five years. However, the enlargement of the EC will increase the market share for the new EC members.

The major topics of the following chapter are theoretical demand and trade models. Several approaches to import demand will be presented and

discussed. Finally, a differential approach will be used to formulate a system of import-demand equations, and the system-wide approach will be used as an estimation process.

CHAPTER 3
METHODOLOGY AND THEORETICAL MODELS

This chapter consists of four sections. The first presents a brief discussion on import-allocation models followed by the system-wide approach and its applications. The second presents methods of deriving demand-equation systems. The third presents the differential approach to import allocation. The last section discusses problems in estimating import-allocation models and their solutions, followed by the derivation of the general form of the differential demand equations under the assumptions of preference independence, block independence, and blockwise dependence, respectively.

An allocation problem in international trade occurs when a country allocates its total import expenditures on a certain group of goods. This allocation problem is similar to the allocation problem faced by a single individual or firm, where the consumer allocates his budget to each commodity such that the maximum level of utility is attained. Therefore, an allocation model based on demand theory can be used as an import-allocation model in international trade (e.g., Barten 1971; Barten et al. 1976; Theil 1980b). In an import-allocation model, the separability assumption can be applied in the context of preferences (i.e., preference independence, block independence, and blockwise dependence). The assumption of separability allows one to partition commodities into groups, so that preferences within groups can be described independently of quantities demanded in other groups. The definitions of strong

separability and weak separability depend on the degree of substitutability between goods in different groups.

In empirical applications of demand-allocation models in international trade, the assumptions of preference independence and block independence have been used to reduce the number of estimated parameters. One of the assumptions, which is applicable but has never been used in international trade literature, is blockwise dependence. More details on these assumptions will be discussed later in this chapter.

The System-wide Approach

One approach for estimating a demand model is the single-equation approach. This approach considers demand equations one by one; therefore, it can not take into account the interaction among related goods. The single-equation approach is appropriate when one assumes that all the goods being estimated are unrelated. However, when estimating demand for a group of related goods, the single-equation approach is no longer appropriate.

An alternative to the single-equation approach is the system-wide approach. The system-wide approach utilizes a system of equations rather than an individual equation. This approach has been used frequently to estimate a system of consumer-demand equations, input-demand equations of a firm, and output-supply equations of a multiproduct firm (Theil 1980b). Recently, the system-wide approach has also been used in estimating import-allocation models (Barten 1971; Armington 1969; Hickman and Lau 1973; Clements and Theil 1978; Theil and Clements 1978; and Winters 1984).

One of the advantages of the system-wide approach over the single-equation approach is that it allows the interdependent relationships among

all goods to be measured. However, there are some shortcomings to this approach as well. One of the problems that may occur in using the system-wide approach is insufficient degrees of freedom when the number of parameters in each equation is larger than the number of available sample observations. In order to limit the number of estimated parameters, one can impose parameter restrictions such as symmetry and additivity. Additionally, one can impose separability on the estimated goods or groups of goods. The implicit assumption of separability is that each group of goods is independent of all other groups. The concept of separability is widely applied in empirical demand studies and in much empirical work in international trade. For example, separability between the demand for imports and domestic goods is usually assumed in import-allocation models (e.g., Armington 1969; Barten 1971; Theil and Clements 1987; and Theil et al. 1989).

Winters (1984) has argued that the traditional assumption of trade-allocation models, where the demand for domestic and imported goods is separable, is false. In order to support his argument, Winters conducted a test of the separability between domestic and foreign goods using an Almost Ideal Demand System (AIDS) model to estimate the United Kingdom's import demand for manufactured goods from ten supplying countries. He used annual data from 1952 through 1979. His hypothesis of separability between domestic and imported goods was rejected. Winters also tested separability and homotheticity of the Armington model. His results showed that these two assumptions were strongly rejected either as individual hypotheses or as a joint hypothesis. In addition, Winters argued that domestic goods and imported goods are not truly separable; and, therefore, the domestic price should be included in import-allocation models. He

proposed two solutions; one solution is to add the price index of domestic goods to the AIDS model. Even though the additional domestic-price term improved the plausibility and statistical properties slightly, this solution still remained unsatisfactory. Winters' second solution was to add domestic goods as an additional good to the import-allocation model. Again, his results were disappointing and unsatisfactory for several reasons: (1) differences in the nature of the import and domestic data; (2) increase in the size of the model which was already over-parameterized; (3) disparate shares; and (4) the introduction of static theory to a dynamic problem and the use of aggregate data for disaggregate theory. One can argue that the assumption of separability between domestic and foreign goods can be applied in some situations. For example, in this study, where domestic production of fresh grapefruit in the EC is relatively small compared to imports, one can assume that they are separable. However, a test of separability will not be carried out due to the limitation of the data. Next, four approaches in formulating a demand system are presented.

Methods of Deriving Demand-Equation Systems

Before proceeding in the derivation of import-demand models, it is important to understand how systems of demand equations are formulated. In contemporary economic literature, specification of demand systems is expressed directly with certain restrictions imposed or developed using a utility-maximization framework. Although both Marshallian (uncompensated) and Hicksian (compensated) demand functions have been used in past literature, the Marshallian demand functions are more popular and useful in applied economic studies. One of the difficulties in

formulating a demand system is in selecting a functional form. The following presents four approaches which are commonly used to derive the explicit form of the Marshallian demand functions.

The first approach in formulating a demand system is to specify demand equations directly and estimate the system without any reference to the utility function. In this approach, the demand for a good is specified as a simple function of income and prices. The most popular functional form used in this approach is the double-log model (i.e., Houthakker 1957). Although the double-log model is attractive for its simplicity of estimation, it has a major weakness in that it violates the adding-up constraint. In this model, if the expenditure elasticity of good i exceeds unity, the expenditure on good i increases at a faster rate than total expenditure; thus the adding-up constraint, $E = \Sigma_i p_i q_i$ where E is total expenditure on all goods, q_i is the quantity demand for good i and p_i is its price, is violated.

The second approach initially assumes a specific algebraic functional form for the utility function, $U = U(q)$, and then derives a set of the Marshallian demand equations through the maximization of the utility function. Some examples of this approach are the linear-expenditure system (Stone 1954); the quadratic-expenditure system (Pollak and Wales 1978); and the direct-translog model (Christenson et al. 1975). The linear-expenditure system is obtained by strict utility maximization, subject to the budget constraint. For example, in the linear-expenditure system, one can specify a particular algebraic form of the cost function, $C(U, p)$, and differentiate this function with respect to price to obtain a demand system which is a function of utility. Therefore, by taking this demand system and expressing it in terms of income and prices (using an

indirect-utility function), one can obtain a system of demand equations in income and price terms.

The third approach is based on the idea of an indirect-utility function, $V = V(p, E)$. The indirect-utility function, showing the maximum attainable utility for given prices (p) and expenditure (E), is conceptually obtainable by substituting the optimal quantities demanded into the original utility function. An explicit solution for the demand functions corresponding to this indirect-utility function can be obtained by differentiating it with respect to prices and income and applying Roy's theorem to obtain demand equations directly. Examples of this approach are the indirect-addilog model (Houthakker 1957) and the indirect-translog model (Christensen et al. 1975). Additionally, one can specify some algebraic form for the cost (or expenditure) function, such as the almost ideal demand system (AIDS) (Deaton and Muellbauer 1980). However, there are some problems involved in using the translog specification. One of the problems is the accuracy of its approximation. Although the translog function is a second-order approximation, the associated demand functions are only first-order approximations. Therefore, these approximations are only accurate when estimates of the demand system are over small regions; but it is not guaranteed that the approximation is accurate for large regions (Theil 1980b). These second and third approaches rely heavily on the assumption of a specific functional form for the direct and indirect utility functions. In order to use the second and third approaches, one needs to define a proper utility function that would yield a realistic and manageable system of demand equations.

Finally, the fourth approach which can be used to derive a system of demand equations is the differential approach. The differential

approach is based on the idea of taking the total differential of demand with respect to income and price variations. This approach does not require initial algebraic specifications for any function. It allows derivation of the system through completely general demand equations from a general utility function. Some attractive features of this approach are: (1) the parameterization of the system can be done at the last step prior to estimation; (2) the coefficients of the differential approach need not be constant; and (3) this approach clearly distinguishes between the first-order and the second-order effects (i.e., substitution effects of price changes are second-order effects). Examples of this approach are the Rotterdam model (Theil 1980a); the modified Working's model (Theil et al. 1981; Theil and Clements 1987); and the Working's-Slutsky model (Theil et al. 1989).

The differential approach is appealing in empirical application relative to the second and the third approaches, since it does not postulate a particular form for the utility function. In this study, the differential approach will be used in deriving explicit demand-equation systems for a modified Rotterdam/Working's model. Details on the differential approach to import allocation are presented below.

The Differential Approach to Import Allocation

The differential approach has proved useful for the formulation of demand systems. This approach does not require a specification of the algebraic form of the utility function such as with the Klein-Rubin utility function in the linear-expenditure system (LES). Rather, it involves the use of Divisia-price and Divisia-volume indexes (Hicks 1946). The differential approach uses Barten's fundamental matrix equation

(Barten 1964) as a tool to obtain explicit demand equations (Theil et al. 1981). The development of Barten's fundamental matrix equation is provided in an appendix.

The Divisia-price and Divisia-volume indexes are the weighted means of logarithmic price and volume changes with weights equal to the corresponding import budget shares. These indexes can be obtained by taking the total differential of the budget constraint with respect to all n prices and n quantities (Theil et al. 1989). Let total expenditure on imports, E, be

$$E = \Sigma_i p_i q_i \qquad i = 1, \ldots, n \tag{3.1}$$

where $p_1, \ldots, p_n$ are the prices of the n imported goods, and $q_1, \ldots, q_n$ are the corresponding quantities of the n imported goods. By totally differentiating (3.1) with respect to all n prices and n quantities, one obtains

$$dE = \Sigma_i q_i\, dp_i + \Sigma_i p_i\, dq_i \qquad i = 1, \ldots, n \tag{3.2}$$

which is a decomposition of the change in total import expenditures, dE, in terms of a price component ($\Sigma_i q_i\, dp_i$) and quantity component ($\Sigma_i p_i\, dq_i$). Dividing both sides of (3.2) by E one obtains

$$dE/E = \Sigma_i (p_i q_i/E)(dp_i/p_i) + \Sigma_i (p_i q_i/E)(dq_i/q_i)$$

which can be written in the logarithmic form as

$$d(\log E) = \Sigma_i w_i\, d(\log p_i) + \Sigma_i w_i\, d(\log q_i) \tag{3.3}$$

where $d(\log E) = dE/E$, $d(\log p_i) = dp_i/p_i$, $d(\log q_i) = dq_i/q_i$, and $w_i = p_i q_i/E$. This equation indicates that the change in import expenditures equals the

sum of the Divisia-price and Divisia-volume indexes. Additionally, by defining the Divisia-price and Divisia-volume indexes in differential form as

$$d(\log P) = \Sigma_i \, w_i \, d(\log p_i) \tag{3.4}$$

$$d(\log Q) = \Sigma_i \, w_i \, d(\log q_i), \tag{3.5}$$

equation (3.3) can be written as

$$d(\log E) = d(\log P) + d(\log Q). \tag{3.6}$$

The import expenditure share, w_i, in (3.4) and (3.5) is a function of the expenditure level, E, and the price vector, p, and is not a constant.

One can derive a general form of a differential demand system as follows. By totally differentiating the budget share of good i, $w_i = p_i q_i / E$, one obtains

$$dw_i = (q_i/E)\, dp_i + (p_i/E)\, dq_i - (p_i q_i/E^2)\, dE. \tag{3.7}$$

Multiplying the first term on the right-hand side with p_i/p_i and the second term by q_i/q_i one obtains

$$dw_i = (p_i q_i/E)(dp_i/p_i) + (p_i q_i/E)(dq_i/q_i) - (p_i q_i/E)(dE/E).$$

Given that $p_i q_i/E = w_i$ and the identity $dx/x = d(\log x)$, this change in the budget share can be written as

$$dw_i = w_i \, d(\log p_i) + w_i \, d(\log q_i) - w_i \, d(\log E), \tag{3.8}$$

thus dw_i is the sum of price, quantity and total-expenditure components. The quantity component, $w_i \, d(\log q_i)$, is equal to the contribution of good i to the Divisia volume index (3.5). It will be shown later that this

expression is also the dependent variable in the differential demand system.

Next, let the quantity demand for good i be the function of expenditure, E, and prices, p_i, such that

$$(3.9) \qquad q_i = q_i(E, p_1, \ldots, p_n) \qquad i = 1, \ldots, n.$$

Total differentiation of (3.9) gives

$$(3.10) \qquad dq_i = (\partial q_i/\partial E)\, dE + \Sigma_j(\partial q_i/\partial p_j)\, dp_j.$$

Multiplying both sides of (3.10) by p_i/E, the term on the left by q_i/q_i, and the second term on the right by p_j/p_j yields

$$(3.11) \quad (p_iq_i/E)(dq_i/q_i) = p_i(\partial q_i/\partial E)(dE/E) + (p_ip_j/E)\,\Sigma_j(\partial q_i/\partial p_j)(dp_j/p_j).$$

Given that prices p_i and p_j are held constant and using the budget share, $w_i = p_iq_i/E$, and $dx/x = d(\log x)$, equation (3.11) can be expressed as

$$(3.12) \quad w_i\, d(\log q_i) = (\partial p_iq_i/\partial E)\, d(\log E) + \Sigma_j(p_ip_j/E)(\partial q_i/\partial p_j)\, d(\log p_j).$$

By substituting the solution for the price derivatives of the demand functions, $\partial q_i/\partial p_j = \lambda u^{ij} - (\lambda/(\partial\lambda/\partial E))(\partial q_i/\partial E)(\partial q_j/\partial E) - (\partial q_j/\partial E)\, q_i$, from the fundamental matrix equation (A.8) into the second term on the right of (3.12) and rearranging terms, one obtains

$$(3.13) \quad w_i\, d(\log q_i) = (\partial p_iq_i/\partial E)\,[d(\log E) - \Sigma_j w_j\, d(\log p_j)] + \Sigma_j[(\lambda p_ip_ju^{ij}/E) - ((\lambda/E)/(\partial\lambda/\partial E))\,(\partial p_iq_i/\partial E)(\partial p_jq_j/\partial E)]\, d(\log p_j).$$

Further, one can define the marginal share of good i as

$$(3.14) \qquad \theta_i = (\partial p_iq_i/\partial E).$$

This marginal share of good i indicates the change in total expenditure spent on good i as a result of a one-dollar increase in total expenditure. Unlike the expenditure shares, these marginal shares are not always positive. The marginal share, θ_i, is positive for a necessity and negative for an inferior good. However, note that the sum over i (i = 1, . . . , n) of the marginal shares is equal to one.

$$\Sigma_i \theta_i = 1 \qquad i = 1, \ldots, n. \tag{3.15}$$

By using the Divisia-price index (3.4) and the marginal share of good i (3.14), the first term on the right-hand side of (3.13) can be simplified to

$$(\partial p_i q_i/\partial E)\,[d(\log E) - \Sigma_j w_j\, d(\log p_j)] = \theta_i\, d(\log Q). \tag{3.16}$$

Similarly, the price substitution term in (3.13) can be simplified by first defining the expenditure flexibility, ϕ, as

$$\phi = (\lambda/E)/(\partial\lambda/\partial E) = (\partial \log \lambda/\partial \log E)^{-1} < 0. \tag{3.17}$$

Then let the $(i,j)^{th}$ normalized price coefficient, θ_{ij}, be

$$\theta_{ij} = \lambda p_i p_j u^{ij}/\phi E \qquad i,j = 1, \ldots, n \tag{3.18}$$

where λ is the marginal utility of expenditure, ϕ is the expenditure flexibility, and its reciprocal, $1/\phi$, equals the expenditure elasticity of the marginal utility of expenditure, $(\partial\lambda/\partial E)(E/\lambda)$. The u^{ij} is the $(i,j)^{th}$ element of the inverse of the Hessian matrix, U^{-1}. The n x n matrix of $[\theta_{ij}]$ is symmetric positive definite and satisfies the following three constraints:

(3.19) $\Sigma_j \theta_{ij} = \theta_i, \qquad i = 1, \ldots, n;$

(3.20) $\Sigma_i \theta_i = 1;$

(3.21) $\Sigma_i \Sigma_j \theta_{ij} = 1.$

Using equations (3.14), (3.17), (3.18) and (3.19), the second term on the right-hand side of (3.13) can be expressed as

(3.22) $\Sigma_j[(\lambda p_i p_j u^{ij}/E) - ((\lambda/E)/(\partial\lambda/\partial E))(\partial p_i q_i/\partial E)(\partial p_j q_j/\partial E)]\, d(\log p_j)$

$= \phi \Sigma_j \theta_{ij}\, d(\log p_j) - \phi\, \theta_i \Sigma_j \theta_j\, d(\log p_j)$

$= \phi \Sigma_j \theta_{ij} [d(\log p_j) - \Sigma_j \theta_j\, d(\log p_j)]$

$= \phi \Sigma_j \theta_{ij}\, d(\log (p_j/P^*))$

where

$$d(\log P^*) = \Sigma_j \theta_j\, d(\log p_j),$$

which is the Frisch price index. Note that the Frisch price index uses the marginal shares, but not the budget (or average) shares, as weights. Substituting (3.16) and (3.22) into (3.13), a general form of the differential equation for good i can now be represented as

(3.23) $w_i\, d(\log q_i) = \theta_i\, d(\log Q) + \phi \Sigma_j \theta_{ij}\, d[\log (p_j/P^*)]$

where $d[\log (p_j/P^*)] = d(\log p_j) - d(\log P^*)$, which is the change in the j^{th} relative price. Equation (3.23) shall be referred to as an unconditional-demand equation.

The first term on the right-hand side of (3.23), $\theta_i\, d(\log Q)$, is the real-expenditure term of import demand with θ_i being the marginal import share of good i. This real-expenditure term is measured by the Divisia-

volume index and results from two sources: the change in money expenditure on imports, E; and the expenditure effect of price changes. This expenditure effect of price changes, which transforms the change in money expenditure into a real-expenditure change, is equal to θ_i times the Divisia-price index (see equation (3.16)).

The second term on the right-hand side of (3.23), $\phi \sum_j \theta_{ij} d[\log(p_j/P^*)]$, is the price-substitution term, which represents the total-substitution effect of the price changes. This total-substitution term is made up of two components: the specific-substitution effect, $\phi \sum_j \theta_{ij} d(\log p_j)$; and the general-substitution effect of the price changes, represented by the Frisch price index, $d(\log P^*)$.

By combining p_i and its Frisch price index deflator in (3.23), one can directly present the total-substitution effect. Thus (3.23) can be simplified to

$$w_i \, d(\log q_i) = \theta_i \, d(\log Q) + \sum_j \pi_{ij} \, d(\log p_j) \tag{3.24}$$

where π_{ij} is the $(i,j)^{th}$ Slutsky coefficient and is equal to $\phi (\theta_{ij} - \theta_i\theta_j)$. These Slutsky coefficients also satisfy

$$\pi_{ij} = \pi_{ji} \qquad i,j = 1, \ldots, n; \tag{3.25}$$

$$\sum_j \pi_{ij} = 0 \qquad i = 1, \ldots, n, \tag{3.26}$$

which are the symmetry and homogeneity conditions, respectively. The next section briefly discusses the assumptions of preferences in the import-allocation models. Then, the derivation of the general form of differential demand equations under preference independence, block independence, and blockwise dependence are presented.

Preference Assumptions in the Import-Allocation Models

Based on time-series data, an import-allocation model can be estimated as a disaggregated import-demand system or as an aggregated import-demand system. The choice of aggregation depends on several factors, such as the number of observations available and the nature of the data. In general, the direct estimation of a completely disaggregated import-demand system is quite difficult, because of the problem of insufficient degrees of freedom. There are basically two approaches to avoid the degree-of-freedom problems (i.e., aggregation and multi-stage budgeting). In an empirical study, the decision of which approach should be used depends on the purpose of the study. For example, if one is interested in import demand for a broad group of goods, then aggregation is the appropriate approach. But, if the purpose of the study is to estimate import demand for a particular product or small group of products, then the assumption of two- or multi-stage budgeting is appropriate. However, both of these approaches can be applied jointly to the same set of data.

The aggregation process (i.e., aggregation over goods, over consumers or over places of origin) can be done based on the purpose of study, economic intuition or the composite-commodity theorem (Deaton and Muellbauer 1980). Another approach that has often been used to avoid degree-of-freedom problems in empirical analysis is to assume two- or multi-stage budgeting. The application of two- or multi-stage budgeting requires restrictions on the utility function, i.e., separability. Also by imposing the assumption of separability, based on preferences, one can avoid degree-of-freedom problems in estimating the import-allocation model.

There are several assumptions concerning preferences that can be used in developing an import-allocation model. These include preference-independent, block-independent, and blockwise-dependent assumptions. Preference independence assumes that the marginal utility of each good is independent of the consumption of all other goods. Block independence, which is a weaker assumption than preference independence, assumes that the marginal utility of each good within a group is independent of the quantities demanded of all goods that belong to different groups. The assumption of blockwise dependence, which may be viewed as a special case of block independence, assumes that the marginal utility of good i depends on the import of group j, even when j belongs to a different group than i. More details on preference-independent, block-independent, and blockwise-dependent assumptions are presented below.

Preference Independence

In import-allocation models, the assumption of preference independence is reasonable when applied to fairly broad groups of goods such as food, clothing, electronics, and automobiles. Preference independence assumes that the marginal utility of each good is independent of the consumption of all other goods. In other words, preference independence implies that there is no substitution or complementarity among all goods being estimated. This means that the utility function is additive for each good and can be represented as the sum of $u_i(q_i)$ where $i = 1, \ldots, n$.

$$u(q) = u_1(q_1) + \ldots + u_n(q_n) \tag{3.27}$$

or $$u(q) = \sum_{i=1}^{n} u_i(q_i)$$

where q_i is the quantity of good i, and u_i is the utility function which involves only the quantity of good i. This form of utility implies that the marginal utility of good i is a function of q_i only and is independent of the consumption of good j for $i \neq j$. Under preference independence, the Hessian matrix of the utility function and its inverse are both diagonal. It also follows from (3.18) and (3.19) that $\theta_{ij} = 0$ for $i \neq j$ and $\theta_{ii} = \theta_i$. Based on these definitions, the general form of the differential demand equation for good i (3.23) under preference independence can be written as

(3.28) $$w_i \, d(\log q_i) = \theta_i \, d(\log Q) + \phi \, \theta_i \, d[\log (p_i/P')],$$

where only the Frisch-deflated own price appears in each demand equation. Under preference independence, the matrix $[\theta_{ij}]$ is symmetric positive definite, which implies that each of the θ_{ii} is positive. Hence $\theta_{ii} = \theta_i$ implies that the marginal share of each good must be positive, ruling out inferior goods. In addition, preference independence implies that no good is a specific substitute or complement of any other good. The implications of preference independence are strong and rather restrictive. Two weaker assumptions of preferences (block independence and blockwise dependence) are discussed below.

Block Independence.

Block independence is a weaker version of preference independence. Under block independence, the utility function is assumed to be additive for the groups of goods. Therefore, the marginal utility of each good in

one group is independent of the quantities demanded of all goods that belong to different groups. However, block independence allows substitution and complementary relationships among the goods within the same group. Under block independence, the additive specification of a utility function is applied to groups of goods rather than to individual goods. For example, let n goods be aggregated into $G < n$ groups, $S_1, \ldots, S_G$, such that each of the n goods belongs to only one subgroup. Under block-independent preference, the utility function is the sum of G group utility functions, each involving the quantities of only one group,

$$u(q) = u_1(q_1^*) + \ldots + u_G(q_G^*) \tag{3.29}$$

or

$$u(q) = \sum_{g=1}^{G} u_g(q_g^*)$$

where q_g^* is the subvector of q which consists of the q_i's that fall under group S_g. The utility function (3.29) implies that the marginal utility of an imported good depends only on imported goods that belong to the same group. In addition, block independence implies that the Hessian matrix, U, and the matrix of the $(i,j)^{th}$ normalized price coefficient, θ_{ij}, are block-diagonal. That is, for $i \in S_g$, equation (3.23) and (3.19) can now be written as

$$w_i \, d(\log q_i) = \theta_i \, d(\log Q) + \phi \sum_{j \in S_g} \theta_{ij} \, d\,[\log (p_j/P^*)] \tag{3.30}$$

and

$$\sum_{j \in S_g} \theta_{ij} = \theta_i, \qquad i \in S_g \,. \tag{3.31}$$

The import-demand equation (3.30) implies that the only deflated prices appearing in the i^{th} import-demand equation are those that belong to the

same group S_g, and $\theta_{ij} = 0$ for goods i and j that belong to different groups than S_g.

Under block independence, a group of goods as a whole cannot be inferior; however, an individual good within each group can be inferior. Block independence also implies that no good is a substitute or a complement of any good that belongs to a different group.

Import demand for a group of goods under block independence. One can also estimate the demand for a group of imported goods using block independence. Further, conditional on the demand for the groups, one can estimate the demand for goods within each group. Consider the situation where import expenditure is allocated among G groups of goods. The demand equation for group S_g as a whole, under block independence, can be obtained by adding $i \in S_g$ to both sides of (3.30) and can be expressed as

$$(3.32) \qquad W_g \, d(\log Q_g) = \theta_g \, d(\log Q) + \phi \sum_{i \in S_g} \sum_{j \in S_g} \theta_{ij} \, d\,[\log (p_j/P^*)]$$

where

$W_g = \sum_{i \in S_g} w_i$ -- the budget share of group S_g

$\theta_g = \sum_{i \in S_g} \theta_i$ -- the marginal share of group S_g and satisfies $\sum_{i \in S_g} \sum_{j} \theta_{ij} = \theta_g$

$d(\log Q_g) = \sum_{i \in S_g} (w_i/W_g) \, d(\log q_i)$ -- the Divisia volume index for group

$d(\log Q) = \sum_{g=1}^{G} W_g \, d(\log Q_g)$ -- the overall Divisia volume index of all the n goods which is equal to a budget-share weighted average of $d(\log Q_1), \ldots, d(\log Q_G)$

$d(\log P_g^*) = \sum_{i \in S_g} (\theta_i/\theta_g) \, d(\log p_i)$ -- the Frisch price index for group S_g

$$d(\log P^*) = \sum_{g=1}^{G} \theta_g \, d(\log P_g^*)$$ -- the overall Frisch price index which is equal to a marginal-share weighted average of $d(\log P_1^*)$, . . . , $d(\log P_G^*)$.

Summing both sides of the price-substitution term (3.31) over $i \in S_g$ yields

$$(3.33) \qquad \sum_{i \in S_g} \sum_{j \in S_g} \theta_{ij} = \sum_{i \in S_g} \theta_i = \theta_g$$

where θ_g is the marginal share of group S_g. This marginal share indicates how much import expenditure on S_g would increase as a result of a one-dollar increase in total import expenditure. According to (3.33), one can rewrite (3.32) as

$$(3.34) \qquad W_g \, d(\log Q_g) = \theta_g \, d(\log Q) + \phi \, \theta_g \, d\,[\log (P_g^*/P^*)],$$

which is the import-demand equation for S_g as a group under block independence. Equation (3.34) is equivalent to the uppercase version of the preference-independent demand equation (3.28). This equation shows that the import demand for a group of goods as a whole depends on real expenditure and the relative price of the group. One can obtain the import-expenditure elasticity and the Frisch own-price elasticity of demand for S_g by dividing both sides of (3.34) by W_g

$$(3.35) \qquad d(\log Q_g) = (\theta_g/W_g) \, d(\log Q) + \phi \, (\theta_g/W_g) \, d[\log (P_g^*/P^*)],$$

where

$$(3.36) \quad \theta_g/W_g = N_g$$ -- the import-expenditure elasticity of demand for the group S_g

$$(3.37) \quad \phi_g = \phi \, \theta_g/W_g$$ -- the Frisch own-price elasticity for the group S_g as a whole.

Conditional import demand for individual goods under block independence. By using the concept of multi-stage budgeting, one can estimate the demand for an imported good conditional on the import demand for its group of imported goods. In order to derive the conditional import-demand equations for individual goods under block independence, one can first rearrange equation (3.34) as

$$(3.38) \qquad d(\log Q) = (W_g/\Theta_g)\, d(\log Q_g) - \phi\, d[\log (P_g^*/P^*)].$$

Next, substituting this on the right-hand side for d(log Q) in (3.30) gives

$$(3.39) \qquad w_i\, d(\log q_i) = (\theta_i/\Theta_g)\, W_g\, d(\log Q_g) - \phi\, \theta_i\, d(\log P_g^*) + \phi\, \theta_i\, d(\log P^*) + \phi \sum_{j \in S} \theta_{ij}\, d(\log p_j) - \phi \sum_{j \in S_g} \theta_{ij}\, d(\log P^*).$$

One can use equation (3.31) to rewrite the second and third terms on the right-hand side of (3.39) as

$$(3.40) \qquad -\phi\, \theta_i\, d(\log P_g^*) = -\phi \sum_{j \in S_g} \theta_{ij}\, d(\log P_g^*)$$

$$(3.41) \qquad \phi\, \theta_i\, d(\log P^*) = \phi \sum_{j \in S_g} \theta_{ij}\, d(\log P^*).$$

Substituting (3.40) and (3.41) back into (3.39) and rearranging the terms, equation (3.39) can be expressed as

$$(3.42) \qquad w_i\, d(\log q_i) = (\theta_i/\Theta_g)\, W_g\, d(\log Q_g) + \phi \sum_{j \in S_g} \theta_{ij}\, d[\log (p_j/P_g^*)].$$

By dividing both sides of (3.42) by W_g and multiplying the second term on the right-hand side by θ_g/θ_g, one can write the conditional import-demand equation for good i within its group as

$$(3.43)\quad (w_i/W_g)\, d(\log q_i) = (\theta_i/\theta_g)\, d(\log Q_g) + (\phi\theta_g/W_g) \sum_{j\in S_g} (\theta_{ij}/\theta_g)\, d[\log (p_j/P_g^*)].$$

This equation (3.43) can be simplified to

$$(3.44)\quad w_i^*\, d(\log q_i) = \theta_i^*\, d(\log Q_g) + \phi_g \sum_{j\in S_g} \theta_{ij}^*\, d[\log (p_j/P_g^*)]$$

where

$w_i^* = w_i/W_g$ -- the conditional budget share of good i within group S_g for $i \in S_g$ which satisfies $\sum_{i\in S_g} w_i^* = 1$

$\theta_i^* = \theta_i/\theta_g$ -- the conditional marginal share of good i within group S_g for $i \in S_g$ which satisfies $\sum_{i\in S_g} \theta_i^* = 1$

$\theta_{ij}^* = \theta_{ij}/\theta_g$ -- normalized price coefficient within the group, $i,j \in S_g$, which satisfies $\sum_{j\in S_g} \theta_{ij}^* = \theta_i^*$ for $i\in S_g$

$\phi_g = \phi\, \theta_g/W_g$ -- the Frisch own-price elasticity of import demand for the group S_g.

Blockwise Dependence

Another assumption that may be viewed as a special case of block independence is blockwise dependence. The assumption of blockwise dependence is less restrictive than that of block independence. Under blockwise dependence, the utility function for groups of goods is no

longer additive; instead, it is some increasing function f(), of the group utility functions,

$$u(q) = f(u_1(q_1^*), \ldots, u_G(q_G^*)) \tag{3.45}$$

where q_g^* is a subvector of q which consists of q_i's in group S_g (Theil et al. 1989). The utility function under blockwise dependence implies that the marginal utility of good i depends on the import of good j, even when j belongs to a different group than i. In addition, blockwise dependence allows the relative prices of other groups of goods to enter into the price-substitution term. For any two-stage budgeting procedure under blockwise dependence, import demand for groups of goods in the first stage is similar to that of block independence, except for the price-substitution term.

Import demand for a group of goods under blockwise dependence. Under blockwise dependence, import demand for group S_g depends on the relative prices of goods in its own group and in all other groups. Let $i \in S_g$, $j \in S_h$ $(g \neq h)$, and the marginal shares of group S_g be

$$\theta_g = \sum_{h=1}^{G} \theta_{gh} \tag{3.46}$$

where

$$\theta_{gh} = \sum_{i \in S_g} \sum_{j \in S_h} \theta_{ij} \qquad g, h = 1, \ldots, G.$$

This G x G matrix $[\theta_{gh}]$ is symmetric positive definite. Note that under blockwise dependence, a group of goods as a whole can be inferior. This is represented by a negative marginal share of that group. By using notation (3.46) above, the composite import-demand equation for group S_g under blockwise dependence may be represented as

$$(3.47) \quad W_g \, d(\log Q_g) = \theta_g \, d(\log Q) + \phi \sum_{h=1}^{G} \theta_{gh} \, d[\log (P_h^*/P^*)].$$

One can obtain the import-expenditure elasticity and the Frisch own-price elasticity of demand for group S_g by dividing both sides of (3.47) by W_g

$$(3.48) \quad d(\log Q_g) = (\theta_g/W_g) \, d(\log Q) + (\phi \sum_{h=1}^{G} \theta_{gh}/W_g) \, d[\log (P_h^*/P^*)]$$

where

(3.49) θ_g/W_g -- the import-expenditure elasticity of demand for group S_g

(3.50) $\phi_{gg} = \phi \, \theta_{gg}/W_g$ -- the Frisch own-price elasticity for group S_g as a whole.

Conditional import demand for individual goods within group S_g under blockwise dependence. The conditional import-demand equation for good i, when $i \in S_g$ under blockwise dependence, can be written as

$$(3.51) \quad w_i \, d(\log q_i) = (\theta_i/\theta_g) W_g \, d(\log Q_g) + \phi \sum_{j \in S_g} \theta_{ij} \, d[\log (p_j/P_g^*)].$$

Dividing both sides of (3.51) by W_g and multiplying the second term on the right-hand side by θ_{gg}/θ_{gg} yields

$$(3.52) \quad (w_i/W_g) \, d(\log q_i) = (\theta_i/\theta_g) \, d(\log Q_g) + (\phi\theta_{gg}/W_g) \sum_{j \in S_g} (\theta_{ij}/\theta gg)$$

$$d[\log (p_j/P_g^*)].$$

Equation (3.52) can be simplified to

$$(3.53) \quad w_i^* \, d(\log q_i) = \theta_i^* \, d(\log Q_g) + \phi_{gg} \sum_{j \in S_g} \theta_{ij}^* \, d[\log (p_j/P_g^*)]$$

where

$w_i^* = w_i/W_g$ -- the conditional budget share of good i within group S_g

$\theta_i^* = \theta_i/\Theta_g$ -- the conditional marginal share of good i within group S_g which satisfies $\theta_i^* = \sum_{j\in S_g} \theta_{ij}^*$ for $i\in S_g$

$\theta_{ij}^* = \theta_{ij}/\Theta_{gg}$, -- $i\in S_g$, $j\in S_g$ is normalized price coefficient

$\phi_{gg} = \phi\ \Theta_{gg}/W_g$ -- the Frisch own-price elasticity for group S_g group S_g as a whole.

Equation (3.53) represents the conditional import demand for good i within the S_g group under blockwise dependence.

Among these three assumptions of preferences, block independence and blockwise dependence are more appealing in the empirical analysis of import demand than preference independence, since the implication of preference independence is strong and rather restrictive. In order to estimate an import-demand system, one can assume preference independence or block independence at any stage in an allocation model. Additionally, when there is a linkage between any two stages, the assumptions of the import-demand system depend on the assumptions of both the first and the second stages. For example, if the first-stage budget is assumed to be preference independence and the second-stage budget is assumed to be block independence, then the two-stage budgeting model can be estimated under the block-independent assumption. However, if both the first- and the second-stage budgets are assumed to be block independent, then the two-stage budgeting model can be estimated under the blockwise-dependent assumption. The assumption of preference independence should be used when estimating a system of import demand for broad groups of goods that are independent of each other (i.e., food, clothing, and automobiles). However, when estimating import demand for a particular good or group of

goods that are closely related, the assumption of block independence or blockwise dependence should be used.

Under the assumption of multi-stage budgeting, an import-allocation model can be solved in two (or more) steps. First, an importing country or region allocates its total import expenditure (or import expenditure conditional on the higher level allocation) to groups of imported goods and then, conditional on the first-stage expenditure, allocates the given budget for a particular good within the group. Furthermore, conditional on the expenditure of each good, an importing country can further allocate its expenditure on that particular good among export suppliers.

The next chapter is concerned with the development of Working's model (Working 1943). This includes the derivation of an unconditional and a conditional Working's model. Then, a conditional version of a modified Rotterdam/Working's model is formulated under the assumption of blockwise dependence. This is followed by a parameterization of the import-demand equation for groups of goods and for an individual good within the group.

CHAPTER 4
MODEL SPECIFICATION:
A MODIFIED ROTTERDAM/WORKING'S MODEL

This chapter presents a summary of Working's model (Working 1943) and the Rotterdam model (Theil 1976). A modified Rotterdam/Working's model is developed by combining the two models to overcome several weaknesses of using the models separately. The following consists of three sections. The first discusses Working's model. Derivation of an unconditional and a conditional Working's model will be presented. The second presents the derivation of a finite-change version of the Rotterdam model. In the third section, a modified Rotterdam/Working's[1] model is presented. This model is derived by parameterizing the general form of the differential demand equation via both the Rotterdam and Working's model.

Working's Model

Working's model (Working 1943), which will be referred to as Working's model from here on, specifies that the budget share of each good is a linear function of the logarithm of expenditure (income), $w_i = \alpha_i +$

[1] The modified Rotterdam/Working's model is developed from the general form of the differential approach. This model followed the idea of a modification to the Working's model developed by Theil and Clements (1987, pp. 205-206), and Theil et al. (1989, pp.183-184). With this approach, one starts from the conditional absolute prices version of the Rotterdam model and substitutes the marginal share implied by Working's model (Working). The approach taken by Theil et al. (1989) is referred to as the Working-Slutsky model. Here, one takes Working's Engel curve model as the starting point and applies a price-substitution term under preference-independence.

$\beta_i \log E + \epsilon_i$. Furthermore, the marginal share, θ_i, in this model is equal to $w_i + \beta_i$ and is not a constant. The original Working's model (Working 1943) was used to analyze household-expenditure data allocated to food. Working found that the total expenditure allocated to food (budget share of food) tends to decline linearly with the logarithm of total expenditure. One feature of Working's model is that it does not contain prices, because the prices of all n goods are assumed to be fixed at a certain value. Thus, Working's model is sometimes referred to as an Engel curve model. In the following section, two versions (unconditional and conditional) of Working's model will be described.

An Unconditional Working's Model

In an unconditional Working's model, all n goods are included as an individual good. This model can be represented as

$$(4.1) \qquad w_i = \alpha_i + \beta_i \log E, \qquad i = 1, \ldots, n,$$

where the total expenditure $E = \Sigma_i p_i q_i$, p_i is the price of good i, q_i is the quantity of good i, $w_i = p_i q_i / E$ is the budget share of good i, and α_i and β_i are the parameters to be estimated. Given that the sum of the budget shares is unity, $\Sigma_i w_i = 1$, it follows from (4.1) that the α_i's and β_i's are subject to the constraint,

$$\Sigma_i \alpha_i = 1 \quad \text{and} \quad \Sigma_i \beta_i = 0.$$

The marginal shares of good i, $\theta_i = \partial(p_i q_i)/\partial E$, implied by Working's model, can be derived by multiplying (4.1) by E, which gives $p_i q_i = \alpha_i E + \beta_i E \log E$, and then differentiating this equation with respect to E,

$$(4.2) \qquad \partial(p_i q_i)/\partial E = \alpha_i + \beta_i (1 + \log E).$$

Using (4.1), this marginal share can be written as,

$$\theta_i = w_i + \beta_i. \qquad (4.3)$$

Thus, under Working's model, the marginal share of good i exceeds the corresponding budget share by β_i. Even though β_i is constant with respect to total expenditure (E), the budget share (w_i) is variable; therefore, the marginal share (θ_i) is not a constant. However, these marginal shares must satisfy the adding-up property, $\Sigma_i \theta_i = 1$.

The expenditure elasticity, η_i, for this model is the ratio of the marginal share to its corresponding budget share. This elasticity can be obtained by dividing both sides of (4.3) by w_i

$$\eta_i = \theta_i/w_i = 1 + \beta_i/w_i. \qquad (4.4)$$

The expenditure elasticity in this model is a more plausible outcome than the expenditure elasticities under the linear expenditure system (Theil and Clements 1987).

A Conditional Working's Model

In a conditional Working's model, all n goods are grouped into G subgroups, $S_1, \ldots, S_G$, such that each good belongs to only one subgroup. The total expenditure (E) is firstly allocated on G groups of goods. Secondly, conditional on the expenditure for S_g, the group expenditure, E_g, is allocated among all goods within this group. Under this conditional version, aggregation over goods under Working's model for a group of goods can be obtained by summing equation (4.1) over $i \in S_g$ which gives

(4.5) $W_g = A_g + B_g \log E$

where $W_g = \sum_{i \in S_g} w_i$ and is the budget share for group S_g. The intercept and slope of this model can be obtained by simply summing up α_i and β_i over $i \in S_g$:

(4.6) $A_g = \sum_{i \in S_g} \alpha_i$ and $B_g = \sum_{i \in S_g} \beta_i$.

The marginal shares of group S_g, θ_g, implied by Working's model can be obtained by summing over $i \in S_g$ on both sides of (4.3)

(4.7) $\sum_{i \in S_g} \theta_i = \sum_{i \in S_g} w_i + \sum_{i \in S_g} \beta_i$.

Using the definition of the budget share of group S_g, $W_g = \sum_{i \in S_g} w_i$, and equations (3.33) and (4.6), one can rewrite (4.7) as

(4.8) $\theta_g = W_g + B_g \qquad g = 1, \ldots, G.$

The expenditure elasticity of demand for each group can be obtained by dividing both sides of (4.8) by W_g

(4.9) $N_g = \theta_g / W_g = 1 + (B_g / W_g)$.

By assuming that the expenditure elasticity of demand for S_g as a group is approximately unity, the conditional Engel curves are approximately in the Working form.

Then, for $i \in S_g$, the conditional Working's model is

(4.10) $w_i^* \approx \alpha_i^* + \beta_i^* \log E_g$

where,

$w_i^* = w_i / W_g$ -- the conditional budget share of $i \in S_g$

$W_g = \sum_{i \in S_g} w_i$ -- the budget share of group S_g

$$E_g = \sum_{i \in S_g} p_i q_i$$ -- total expenditure of group S_g, and

α_i^*s and β_i^*s are constants and must satisfy the following constraints,

$$(4.11) \qquad \sum_{i \in S_g} \alpha_i^* = 1 \quad \text{and} \quad \sum_{i \in S_g} \beta_i^* = 0.$$

Similar to that of an unconditional model, the marginal share for groups of goods, $\theta_i^* = \partial(p_i q_i)/\partial E_g$, can be obtained by multiplying (4.10) by E_g and then differentiating with respect to E_g. One then gets

$$(4.12) \qquad \partial(p_i q_i)/\partial E_g = \alpha_i^* + \beta_i^* (1 + \log E_g), \qquad i \in S_g.$$

By using (4.10), one can also write this equation as

$$(4.13) \qquad \theta_i^* = w_i^* + \beta_i^* \qquad i \in S_g.$$

Again, this equation must satisfy the adding-up condition, $\Sigma_i \theta_i^* = 1$. Thus, the conditional expenditure elasticity for $i \in S_g$ is

$$(4.14) \qquad \eta_i^* = \theta_i^*/w_i^* = 1 + \beta_i^*/w_i^*.$$

When dealing with cross-country import demand, where relative prices of imported goods from different countries are not equal, Working's model is no longer appropriate (Theil et al. 1981). This is because Working's model does not allow prices of all n goods to vary. Since budget shares also correspond to different prices, especially with time-series data, an appropriate correction to Working's model is necessary. One way to correct this problem is to modify Working's model by adding a price-substitution term into the demand equation (Theil et al. 1981; Theil and Clements 1987; Theil et al. 1989). This additional price-substitution

term, which is necessary for an application of time-series, allows one to estimate price elasticities. Another way to correct for this problem is to use a modified Rotterdam/Working's model. The derivation of this model will be provided in full detail following the next section. In the next section, a conditional version of the Rotterdam model will be presented.

The Rotterdam Model

The Rotterdam model is based on the first-order approximation of the demand equations (3.9) (Theil 1976). This model is a system of demand equations derived from the differential approach (Theil 1980a, 1980b). In deriving the Rotterdam model, one starts from a general form of the differential equation for good i. By introducing the subscript t to represent time period t, equation (3.23) can be written as

$$(4.15) \quad w_{it}\, d(\log q_{it}) = \theta_i\, d(\log Q_t) + \phi \sum_j \theta_{ij} [d(\log p_{jt}) - d(\log P_t^*)].$$

This equation is formulated in terms of infinitesimal logarithmic changes. However, it can be represented in a finite-change form through the following procedure. For any positive variable x, one can write the finite log-change from time period t-1 to time period t as

$$(4.16) \quad Dx_t = \log x_t - \log x_{t-1} = \log(x_t/x_{t-1}).$$

In order to write the differential equation in the finite log-change form, one can use either w_{it} or $w_{i,t-1}$ as a weight, since the budget share (w_i) is not affected by the log change. Additionally, one can use the mean (i.e., the arithmetic mean and geometric mean) of the two budget shares as a weight. In this study, the arithmetic average will be used. The

arithmetic average of the budget share in time period t-1 and time period t can be written as

$$(4.17) \qquad \bar{w}_{it} = (w_{i,t-1} + w_{it})/2.$$

By replacing the infinitesimal log changes, $d(\log p_i)$ and $d(\log q_i)$, with the finite log changes, Dp_{it} and Dq_{it}, and using equation (4.17) as weights, the Divisia-price and Divisia-volume indexes, (3.4) and (3.5), can be written in the finite-change form as

$$(4.18) \qquad DP_t = \Sigma_i \bar{w}_{it} Dp_{it}$$ -- the Divisia-price index in the finite-change form

and

$$(4.19) \qquad DQ_t = \Sigma_i \bar{w}_{it} Dq_{it}$$ -- the Divisia-volume index in the finite-change form.

Using equations (4.17) and (4.19), the general form of the differential equation for good i, (4.15), can be represented in the finite-change version as

$$(4.20) \qquad \bar{w}_{it} Dq_{it} = \theta_i DQ_t + \phi \Sigma_j \theta_{ij} (Dp_{jt} - DP_t^*)$$

where

$d(\log q_{it}) = Dq_{it} = \log (q_{it}/q_{i,t-1})$ -- the quantity log change

$d(\log p_{jt}) = Dp_{jt} = \log (p_{jt}/p_{j,t-1})$ -- the price log change

$DP_t^* = \Sigma_j \theta_j Dp_{jt}$ -- the finite-change version of the Frisch price index.

Equation (4.20) is known as the relative price version of the Rotterdam model for a system of demand equations (Barten 1964; Theil

1965). The parameters, ϕ, θ_i, and θ_{ij}, in this model are assumed to be constant over time and subject to the following constraints:

$$\phi < 0; \quad \Sigma_i \theta_i = 1 \; ; \quad \text{and } \Sigma_i \theta_{ij} = \theta_i.$$

In addition, the matrix $[\theta_{ij}]$ is symmetric positive definite. By combining the Frisch price index (DP_t^*) with the price log change (Dp_{jt}), and rearranging the terms, equation (4.20) can be written as

$$\bar{w}_{it} Dq_{it} = \theta_i DQ_t + \phi \Sigma_j \theta_{ij} Dp_{jt} - \phi (\Sigma_j \theta_{ij}) \Sigma_j \theta_j Dp_{jt}$$

$$\bar{w}_{it} Dq_{it} = \theta_i DQ_t + \phi \Sigma_j (\theta_{ij} - \theta_i\theta_j) Dp_{jt}$$

$$\bar{w}_{it} Dq_{it} = \theta_i DQ_t + \Sigma_j \pi_{ij} Dp_{jt}. \tag{4.21}$$

where

$$\pi_{ij} = \phi (\theta_{ij} - \theta_i\theta_j) \qquad i,j = 1, \ldots, n.$$

Equation (4.21) is known as the absolute price version of the Rotterdam model for a system of demand equations. The parameters π_{ij}'s are the Slutsky coefficients, and the n x n matrix of $[\pi_{ij}]$ is symmetric negative semidefinite of rank n-1. In addition, these π_{ij} must also satisfy the homogeneity and symmetry conditions, $\Sigma_j \pi_{ij} = 0$ and $\pi_{ij} = \pi_{ji}$, for i,j = 1, . . . , n.

Even though the Rotterdam model has been used as an import-allocation model in past studies, it does have a disadvantage. The disadvantage of the Rotterdam model stems from the assumption that the marginal share for a group of goods or for an individual good (θ_g or θ_i) is constant. In fact, the estimated expenditure and price elasticities from import-allocation models using time-series data are typically not

constant but vary through time. In past literature, this problem has been avoided by estimating the expenditure and price elasticities at the sample means. However, by allowing some modifications in this model, more details on the annual estimation are obtainable.

Given the shortcomings in Working's model and the Rotterdam model described earlier, a modified Rotterdam/Working's model, which includes the price term and allows the marginal share to vary with expenditure levels over time, will be developed in the following section.

A Modified Rotterdam/Working's Model

A modified Rotterdam/Working's model is developed through the differential approach by combining certain elements of both the Rotterdam and Working's model. The advantage of a modified Rotterdam/Working's model is that it allows one to estimate the expenditure and price elasticities, which vary for each year, without violating any economic intuition. A modified Rotterdam/Working's model can be applied to both conditional and unconditional versions of import-demand allocation models.

An unconditional version of a modified Rotterdam/Working's model refers to an import-demand equation where the allocation of expenditure to good i depends on total import expenditure and the relative prices of all imported goods. An unconditional import-demand system implies that $\Sigma_i w_i = 1$. An example of this version is an import-demand equation under preference independence (i.e., equation (3.28)).

A conditional version of the modified Rotterdam/Working's model refers to all imported goods, which are grouped together into G subgroup, $S_1, \ldots, S_G$, and each good belongs to only one subgroup. For $i \in S_g$, the allocation of expenditure to goods within the S_g group depends on the

total expenditure for the group and the relative prices of goods within the group. Examples of this version are the import-demand equations under block independence (3.44) and blockwise dependence (3.53).

The major interest in this study is to estimate the impact of changes in import prices and expenditure on the import demand in the EC for fresh fruits as a group, and on fresh grapefruit, assuming grapefruit from different suppliers are individual, differentiated goods. Multi-stage budgeting under blockwise dependence will be used with time-series data. In this context, a conditional version of a "modified Rotterdam/Working's" model is developed and utilized.

A conditional version of the modified Rotterdam/Working's model is derived by parameterizing the general form of differential demand equation via the Rotterdam and Working's model discussed earlier. In the modified Rotterdam/Working's model, one can apply the concept of separability based on preference assumptions. The separability assumption allows a country or group of countries to allocate its total import expenditure in two or more stages. For example, Theil and Clements (1978) and Theil et al. (1981, 1989) used the separability assumption in international consumption studies. In this analysis, therefore, an expenditure allocation between domestic and imported goods is assumed to be separable. This assumption is based on the fact that production of fresh grapefruit in the EC is relatively small, compared to imports. Therefore, the demand for fresh fruit imports can be estimated independently from domestic consumption. Essentially, an import-allocation model for the EC is utilized with a three-stage budgeting procedure. In the first-stage allocation, import demands between imported fresh fruits and other imported goods are assumed to be strongly separable, or preference independent. In the second-stage

allocation, the import-expenditure condition on fresh fruits as a whole is allocated among four groups of fresh fruits under block independence. These four groups are, S_1, . . . , S_4, where 1 = fresh grapefruit, 2 = fresh oranges, 3 = other fresh citrus, excluding grapefruit and oranges, and 4 = other fresh fruits, excluding fresh citrus. Imported fresh grapefruit from different suppliers are considered to be different products that belong to S_1. Then, conditional on import expenditure for fresh grapefruit, the EC further allocates this expenditure among four groups of suppliers of fresh grapefruit at the third stage. The conditional import-demand equations for fresh grapefruit from four different suppliers will be derived under the block-independent preference assumption. These four groups are h_1, . . . , h_4, where 1 = imported fresh grapefruit from the U.S., 2 = imported fresh grapefruit from Israel and Cyprus, 3 = imported fresh grapefruit from the rest of the world in the northern hemisphere (ROWN), and 4 = imported fresh grapefruit from the rest of the world in the southern hemisphere (ROWS).

By focusing on the second and third stages, one can link these two stages together and estimate them as a two-stage budgeting problem under the blockwise-dependence assumption. Import-demand equations for the first stage will not be estimated, and the test for the blockwise-dependence assumption will not be carried out, due to the limitation of available data. The following section provides parameterization of an import-demand equation for group of goods, S_g, and a conditional import-demand equation for the individual good i for $i \in S_g$, respectively. In the following model, the subscript t is introduced to represent time period t for time-series application.

Parameterization of the Import-Demand Equation for a Groups of Goods under the Blockwise-Dependent Assumption.

By combining $\log P_h^*$ and its Frisch price index deflator $\log P^*$ and introducing subscript t to represent time, one can rewrite equation (3.47) in terms of the absolute price version as

$$(4.24) \qquad \bar{W}_{gt}\, d(\log Q_{gt}) = \theta_g\, d(\log Q_t) + \sum_{h=1}^{G} \Pi_{gh}\, d(\log P_{ht}^*)$$

where

$$\bar{W}_{gt} = (W_{g,t-1} + W_{gt})/2$$

$$\Pi_{gh} = \phi(\theta_{gh} - \theta_g\theta_h).$$

The variable $\bar{W}_{gt}$ is the arithmetic mean of the expenditure share of group S_g imported into the EC during time periods t and t-1. The Π_{gh} is the $(g,h)^{th}$ conditional Slutsky coefficient for the group. The n x n matrix of $[\Pi_{gh}]$ is symmetric and negative semidefinite. These Slutsky coefficients also satisfy the symmetry and homogeneity conditions

$$\Pi_{gh} = \Pi_{hg} \quad \text{and} \quad \sum_{h=1}^{G} \Pi_{gh} = 0, \qquad g,h = 1, \ldots, G.$$

Now, define the variables in (4.24) as

$$(4.25) \qquad d(\log Q_{gt}) = DQ_{gt} = \sum_{i \in S_g} (\bar{w}_{it}/\bar{W}_{gt})\, Dq_{it}$$

$$(4.26) \qquad d(\log Q_t) = DQ_t = \Sigma_i\, \bar{w}_{it}\, Dq_{it}$$

and

$$(4.27) \qquad d(\log P_{ht}^*) = DP_{ht}^* = \log (P_{ht}/P_{h,t-1}).$$

Using (4.25), (4.26) and (4.27), equation (4.24) can be rewritten as

$$(4.28) \qquad \bar{W}_{gt}\, DQ_{gt} = \theta_g\, DQ_t + \sum_{h=1}^{G} \Pi_{gh}\, DP_{ht}^{*}.$$

The conditional version of the import demand of the modified Rotterdam/Working's model for group S_g can be obtained by substituting the expression of the marginal shares of group S_g (4.8) into (4.28) and rearranging the term

$$(4.29) \qquad \bar{W}_{gt}\,(DQ_{gt} - DQ_t) = B_g\, DQ_t + \sum_{h=1}^{G} \Pi_{gh}\, DP_{ht}^{*}.$$

Equation (4.29) will be used to estimate a system of import demand for fresh fruits in the second-stage allocation.

Parameterization of the Conditional Import-Demand Equation for an Individual Good within the Group under the Blockwise-Dependent Assumption.

By introducing the subscript t to represent time period t for time-series application, one can rewrite equation (3.53) as

$$(4.30) \qquad \bar{w}_{it}^{*}\, d(\log q_{it}) = \theta_i^{*}\, d(\log Q_{gt}) + \phi_{gg} \sum_{j \in S_g} \theta_{ij}^{*}\, d[\log (p_{jt}/P_{gt}^{*})],$$

where $\bar{w}_{it}^{*} = \bar{w}_{it}/\bar{W}_{gt}$ is the arithmetic average of the conditional budget share of good i within S_g group, and $\bar{W}_{gt} = \sum_{i \in S_g} \bar{w}_{it}$ is the arithmetic average of the expenditure share for total fresh grapefruit imports. The variable $\theta_i^{*} = \theta_i/\theta_g$ for $i \in S_g$ is the conditional marginal share of good i within S_g group and satisfies $\sum_{i \in S_g} \theta_i^{*} = 1$; $\theta_{ij}^{*} = \theta_{ij}/\theta_{gg}$ for $i,j \in S_g$ is the normalized price coefficient; and $\phi_{gg} = \phi\, \theta_{gg}/W_g$ is the Frisch own-price elasticity for S_g as a whole. One can simplify and write (4.30) in terms of finite changes as

$$(4.31) \qquad \bar{w}_{it}^{*}\, Dq_{it} = \theta_i^{*}\, DQ_{gt} + \sum_{j \in S_g} v_{ij}\, (Dp_{jt} - DP_{gt}^{*})$$

where

$$d(\log q_{it}) = Dq_{it} = \log (q_{it}/q_{i,t-1}) \qquad \text{-- the quantity log change}$$

$$d(\log Q_{gt}) = DQ_{gt} = \sum_{i \in S_g} (\bar{w}_{it}/\bar{W}_{gt})\, Dq_{it} \qquad \text{-- the weighted sum of the quantity log change}$$

$$d(\log p_{it}) = Dp_{it} = \log (p_{it}/p_{i,t-1}) \qquad \text{-- the price log change}$$

$$d(\log P_{gt}^{*}) = DP_{gt}^{*} = \sum_{i \in S_g}^{G} \theta_i^{*}\, Dp_{it} \qquad \text{-- the Frisch price index in terms of finite changes.}$$

$$v_{ij} = \phi\, \theta_{gg} \theta_i^{*}/W_g = \phi_{gg} \theta_i^{*}, \qquad \text{-- the price coefficient for } i \in S_g.$$

The price coefficients v_{ij} must satisfy the constraint

$$v_{ij} = v_{ji} \qquad i,j \in S_g.$$

By combining Dp_{it} and DP_{gt}^{*}, equation (4.31) can be written in terms of the absolute price version as

$$(4.32) \qquad \bar{w}_{it}^{*}\, Dq_{it} = \theta_i^{*}\, DQ_{gt} + \sum_{j \in S_g} \pi_{ij}^{*}\, Dp_{jt}$$

where π_{ij}^{*} is the $(i,j)^{th}$ conditional Slutsky coefficient and is equal to

$$(4.33) \qquad \pi_{ij}^{*} = v_{ij} - \phi_{gg} \theta_i^{*} \theta_j^{*} \qquad i,j \in S_g.$$

This π_{ij}^{*} measures the effect of a change in the price of good j on the import demand of i, given that other prices and total imports of the group remain constant. The conditional Slutsky coefficients satisfy the demand homogeneity condition,

$$(4.34) \qquad \sum_{j \in S_g} \pi_{ij}^{*} = 0 \qquad i \in S_g.$$

This property states that demand remains unchanged when all prices and money expenditure change proportionately (real expenditure remains unchanged). This coefficient also satisfies the symmetry condition,

$$\pi_{ij}^{*} = \pi_{ji}^{*} \qquad i,j \in S_g. \tag{4.35}$$

When one assumes θ_i^{*} and π_{ij}^{*} to be constants, the model (4.32) is equivalent to the absolute price version of the Rotterdam model.

The conditional version of the modified Rotterdam/Working's model can be obtained by substituting the expression θ_i^{*} from (4.13) in (4.32) and rearranging the terms

$$\bar{w}_{it}^{*} (Dq_{it} - DQ_{gt}) = \beta_i^{*} DQ_{gt} + \sum_{j \in S_g} \pi_{ij}^{*} Dp_{jt}. \tag{4.36}$$

Equation (4.36) will be fitted to the conditional import demand for fresh grapefruit in the EC from four different groups of supplier countries. The subscript i will be referred to four groups of supplier countries of fresh grapefruit into the EC. The parameter $\bar{w}_{it}^{*}$ is the arithmetic average of the conditional import expenditure proportion of fresh grapefruit from country i imported to the EC during time period t-1 and time period t. Dq_{it} and Dp_{it} are the quantity and price log changes of fresh grapefruit imported from country i during time period t. The π_{ij}^{*} are the modified $(i,j)^{th}$ element of the conditional Slutsky matrix. Demand homogeneity, $\sum_j \pi_{ij}^{*} = 0$, and symmetry, $\pi_{ij}^{*} = \pi_{ji}^{*}$, restrictions will be imposed upon estimation.

The underlying assumption for this model is that imported fresh grapefruit from different origins into the EC differs in both varieties and tastes and, therefore, can be treated as different products. The multi-exporter framework will be used for estimation of import demand for

fresh grapefruit in the EC. In the multi-exporter framework, import demands may be contemporaneously correlated through the errors. If the symmetry restriction is to be imposed, least-squares would still be unbiased but no longer efficient; therefore, the seemingly unrelated regression (SUR), which is more appropriate, will be used. The SUR gives unbiased, asymptotically consistent, and efficient estimates for both first- and second-stage-budgeting estimations.

The following chapter provides data sources and the definition of variables used in the analysis. The derivation of expenditure elasticity and three types of price elasticities for fresh grapefruit from four different sources will be presented following the empirical results from the estimation.

CHAPTER 5
EMPIRICAL ANALYSIS

In this chapter, data sources and the aggregation process are provided. The empirical results of this study are presented in two parts. In the first part, the estimated results of the EC import demand for fresh grapefruit are presented. Parameter estimates of EC import demand for fresh grapefruit by suppliers based on annual data from 1975 through 1987 are provided. Results of the conditional expenditure-elasticity estimates and three versions of conditional price-elasticity estimates (Cournot, Slutsky, and Frisch) from the system of four conditional import-demand equations for fresh grapefruits are presented and discussed. In the second part of the empirical analysis, details on aggregation procedures of fresh fruits and results of the import-demand system for four groups of fresh fruits from the second-stage budget in the EC are presented and discussed.

Data Sources and Aggregation Process

The data used in this study were obtained from two major sources: the Statistical Office of the European Community (Eurostat 1975-1987) and the Economics and Statistics Department of the Organization for Economic Co-operation and Development (OECD). Annual data from 1975 through 1987 for quantities and values of imported fresh fruits in the EC countries were obtained from the NIMEXE, the six-digit international trade classification of the European Community (Eurostat 1975-1987). The NIMEXE

classification changes slightly from year to year; however, it is more detailed than the Standard International Trade Classification (SITC) or NACE-CLIO (Itelianer 1986). The quantities and values of 25 classes of imported fresh fruits with 58 categories were reported under the NIMEXE code 800. In addition, fresh grapefruit imports from 60 origins are reported under the NIMEXE code 800.70. Observations for the 13-year period from 1975 through 1987 were used.

The nominal prices for the different groups of fresh fruits and fresh grapefruit from each supplier group were derived by dividing the reported expenditures by quantities. All individual prices were then deflated by their corresponding consumer price indexes. Information on the consumer price index (CPI) was obtained from the OECD Economics and Statistics Department. One critical point concerning the data is the unit value of the goods. The difference in measuring units can produce biased results if not handled properly, especially for a composite of goods. In this study, the values of the EC trade are expressed in European Currency Units (ECU). Since the ECU implicitly involves the exchange rate, it can be used to avoid the problem of differences in measuring unit values.

Based on the hierarchal allocation pattern stated in Chapter 4, one can analyze each stage independently from all other stages. The import-demand system for the EC is categorized as a three-stage import-allocation model. However, the first-stage budget, which is an unconditional demand for all imported goods, will not be estimated due to the limitation of the data. Only the second- and the third-stages, which are import demand for fresh fruits and import demand for fresh grapefruit, will be estimated as a two-stage budget under the assumption of blockwise dependence. The modified Rotterdam/Working's model used in this study considers an

import-demand system for fresh fruits as a second-stage budget and an import-demand system for fresh grapefruit from different origins as a third-stage budget. Following a hierarchal allocation, it is assumed that, in the second-stage budget, the EC allocates its conditional import expenditure among four groups of imported fresh fruits. In the third-stage, conditioned on the import-expenditure allocation for fresh grapefruit, the EC further allocates this expenditure among four groups of fresh grapefruit exporters. Since the number of products and exporting countries exceed the number of observations, it is necessary to aggregate the categories in order to estimate the import-allocation model; this is due to the degree-of-freedom problem. The choice of how to aggregate the data depends upon the purpose of the study, economic intuition, and available data. One can aggregate the data based on the composite commodity theorem, which states that if a group of prices moves in parallel, then the corresponding group of commodities can be treated as a single good (Hicks 1946; Deaton and Muellbauer 1980). However, in empirical analysis, the grouping of goods based on the composite commodity theorem is somewhat limited (Deaton and Muellbauer 1980). For example, if the relative prices are largely independent of the pattern of demand, at least in the long run, then goods that are close substitutes in production should be grouped together.

Since fresh grapefruit from different origins varies in both appearance and taste, it can be considered as different products (for products distinguished by place of origin, see Armington 1969). Based on economic intuition and the major objective of this study, which is to investigate the competitiveness of import demand for fresh grapefruit from the U.S. and from all other supplier countries, fresh grapefruit imports

into the EC are aggregated into four major groups of suppliers. These four groups are: (1) the U.S., (2) Israel and Cyprus, (3) the rest of the world in the northern hemisphere except the U.S., Israel and Cyprus (ROWN), and (4) the rest of the world in the southern hemisphere (ROWS). Note that fresh grapefruit from the northern hemisphere countries are available during the winter months, while fresh grapefruit from the southern hemisphere countries are available during the summer months.

Although the primary emphasis of this study is to estimate import demand for fresh grapefruit in the EC market from four groups of supplier countries, it is useful to have an understanding of the competitiveness of fresh grapefruit among all other fresh fruit imports into the EC. Since import demand for all fresh fruits including fresh grapefruit follows a three-stage budgeting process, empirical estimations of both the second and the third stages are necessary. For a thorough understanding of import demand for fresh grapefruit, an estimation of import demand for fresh fruits from the second stage allocation is carried out in this study. Similar to that of fresh grapefruit, aggregation over goods for fresh fruit imports into the EC is necessary to avoid a degree-of-freedom problem, since only 13 observations are available. Based on the available data and the interest of the study, all fresh fruit imports will be aggregated into four major groups. Fresh grapefruit and fresh oranges will be considered as single product groups that belong to the first and the second group, respectively. Other fresh citrus, except fresh grapefruit and fresh oranges, are combined into the third category. Other fresh fruits excluding fresh citrus are considered as the fourth category. These last two groups will be referred to as "other citrus" and "other fresh fruits", respectively.

In general, elasticity estimates from a complete import-demand system with less restrictive assumptions result in highly conditional estimates. A less conditional elasticity estimate can be obtained by assuming two- or multi-stage budgeting. This assumption allows one to concentrate on a particular sector of an import-demand system. In the following section, estimated results of import demand for fresh grapefruit from four groups of supplier countries will be presented.

The EC Import Demand for Fresh Grapefruit

Equation (4.36) will be fitted to the conditional import demand for fresh grapefruit in the EC from four different groups of supplier countries. This equation can be reintroduced here as

$$(5.1) \qquad \bar{w}_{it}^{*} (Dq_{it} - DQ_{gt}) = \beta_i^{*} DQ_{gt} + \sum_{j \in S_1} \pi_{ij}^{*} Dp_{jt} \qquad i \in S_g.$$

Dependent variables used in the analysis of equation (5.1) are the average conditional budget shares of fresh grapefruit from supplier i during time period t, $\bar{w}_{it}^{*}$, times the difference between the quantity log change from supplier i and the weighted sum of the quantity log change, $Dq_{it} - DQ_{gt}$. The subscript i represents the supplier country or group of countries of fresh grapefruit to the EC where: i = 1 refers to the U.S.; i = 2 refers to Israel and Cyprus (Israel-Cyprus); i = 3 refers to the rest-of-the-world countries in the northern hemisphere excluding the U.S., Israel, and Cyprus (ROWN); and i = 4 refers to the rest-of-the-world countries in the southern hemisphere (ROWS). The subscript g represents all countries supplying fresh grapefruit to the EC, and t represents time (year). The independent variables used in the analysis are the weighted sum of quantity log change, DQ_{gt}, and the price log change, Dp_{it}.

Table 5-1 presents the conditional import-expenditure shares for fresh grapefruit ($\bar{w}_{it}^{*}$) from the four suppliers and the import-expenditure share for total fresh grapefruit ($\bar{W}_{gt}$), conditional on fresh fruit import expenditure, in arithmetic averages form. These data show that, at the sample means, the conditional expenditure shares for fresh grapefruit imported from Israel-Cyprus, the U.S., ROWS, and ROWN are 47.9, 23.7, 20.8 and 7.6 percent, respectively. In general, the import-expenditure share for total imported fresh grapefruit accounted for 5.9 percent of total import expenditure for fresh fruits. Over the years from 1976 to 1987, the conditional import-expenditure share for fresh grapefruit from the U.S., ROWN, and ROWS increased from 21.0, 5.6 and 20.9 percent to 28.9, 8.3 and 22.2 percent, respectively. These increases were at the expense of Israel-Cyprus, whose conditional budget share for fresh grapefruit declined from 52.6 percent in 1976 to 40.6 percent in 1987. During 1976 and 1987, the import-expenditure share for total fresh grapefruit, $\bar{W}_{gt}$, conditional on import expenditure for total fresh fruits, fluctuated between 5.2 and 6.7 percent and averaged 5.9 percent.

Divisia Indexes for Imported Fresh Grapefruit in the EC

The first two columns of Table 5-2 are Divisia-volume (DQ_{gt}) and Divisia-price (DP_{gt}) indexes for fresh grapefruit imports. Divisia price-quantity correlations (ρ_{gt}) are presented in the third column. Following Theil and Clements (1987) these price-quantity correlations are calculated from:

$$\rho_{gt} = \Gamma_{gt} \; / \; (K_{gt} * \Pi_{gt})^{1/2} \qquad (5.2)$$

Table 5-1. The Conditional Import-Expenditure Shares for Fresh Grapefruit from Four Suppliers and the Conditional Import-Expenditure Share for Total Fresh Grapefruit Imports into the European Community, 1976-87.

Year	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]	Total fresh grapefruits[c]
	$\bar{w}_1^*$	$\bar{w}_2^*$	$\bar{w}_3^*$	$\bar{w}_4^*$	$\bar{w}_9$
1976	.20979	.52575	.05594	.20852	.06026
1977	.21065	.53629	.07364	.17942	.05690
1978	.18458	.55797	.07455	.18290	.05432
1979	.20647	.54298	.06017	.19038	.05850
1980	.22792	.51398	.05936	.19874	.06141
1981	.24921	.48543	.06274	.20261	.06096
1982	.25182	.46994	.07246	.20587	.06198
1983	.26939	.42932	.08726	.21404	.05674
1984	.26315	.41606	.10249	.21830	.05302
1985	.23080	.43207	.09910	.23803	.05193
1986	.25183	.43180	.08464	.23172	.06251
1987	.28930	.40572	.08257	.22242	.06748
Mean	.23708	.47894	.07624	.20774	.05909

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Conditional on import expenditure for the total fresh fruits in the EC.

Table 5-2. Divisia Indexes of Total Fresh Grapefruit Imports into the European Community, 1976-87.

Year	Volume index	Price index	Price-quantity correlation[a]
	DQ_g	DP_g	ρ_g
1976	.12033	-.19124	.16734
1977	-.12856	-.11468	-.01093
1978	.10624	-.10183	-.34175
1979	-.04339	.06196	-.50692
1980	.07303	-.04479	.21757
1981	-.03576	-.01480	-.37394
1982	-.03400	-.01355	.32528
1983	-.04304	-.00589	.01009
1984	-.10571	.03265	-.72944
1985	-.07634	.19524	-.77637
1986	.16331	-.20337	-.83269
1987	.10610	-.15204	.82791
Mean	.00850	-.04603	-.16865

[a] Calculated from equation (5.2).

where

$$\Pi_{gt} = \sum_{i \in S_g} \bar{w}_{it}^{*} \, (Dp_{it} - DP_{gt})^2$$

$$K_{gt} = \sum_{i \in S_g} \bar{w}_{it}^{*} \, (Dq_{it} - DQ_{gt})^2$$

$$\Gamma_{gt} = \sum_{i \in S_g} \bar{w}_{it}^{*} \, (Dp_{it} - DP_{gt})(Dq_{it} - DQ_{gt})$$

$$Dp_{it} = \log p_{it} - \log p_{i,t-1}$$

$$Dq_{it} = \log q_{it} - \log q_{i,t-1}$$

$$Dp_{gt} = \sum_{i \in S_g} \bar{w}_{it}^{*} \, Dp_{it}$$

$$Dq_{gt} = \sum_{i \in S_g} \bar{w}_{it}^{*} \, Dp_{it}.$$

The estimated parameters in Table 5-2 indicate that seven out of 12 price-quantity correlation coefficients (ρ_{gt}) are negative and range from -0.83 to 0.83 with an average of -0.17. These figures indicate that there is a tendency for the EC to shift away from fresh grapefruit when price increases are above average. In other words, fresh grapefruit imports are sensitive to price changes. This is true for the U.S. grapefruit exports to the EC, which will be seen later in the analysis.

Results for Fresh Grapefruit Import Demand

The system of four conditional import-demand equations based on (5.1) was estimated using iterative seemingly unrelated regressions (SUR) with Slutsky symmetry and adding-up restrictions imposed. Parameter estimates for the four-equation system are reported in Table 5-3. The conditional expenditure coefficients are positive for the U.S. and negative for the other three groups of exporting countries; all are

Table 5-3. Parameter Estimates of Conditional Import-Demand Equations for Fresh Grapefruit in the European Community Estimated at the Sample Mean.

Exporting Country	Expenditure Coefficient (β_i^*)	Modified Slutsky Coefficient (π_{ij}^*)			
		U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
U.S.	.48156*** (.09516)[c]	-.12079* (.07986)	.15815** (.08558)	.03083* (.01975)	-.06818* (.04512)
Israel-Cyprus	-.29671*** (.11101)		-.16234* (.11339)	.00736 (.02412)	-.00317 (.05937)
ROWN	-.02405 (.02950)			-.01120* (.00793)	.02699** (.01469)
ROWS	-.16080*** (.04975)				.09834* (.06148)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

significantly different from zero at $\alpha = 0.01$, with the exception of ROWN. The positive (negative) coefficient indicates that the products are expenditure elastic (inelastic). The modified conditional Slutsky coefficients are reasonable in signs and magnitude. All own-price coefficients are negative and significantly different from zero at $\alpha = 0.10$, with the exception of the own-price coefficient for ROWS, which has an unexpected positive sign.

The advantage of this modified Rotterdam/Working's model is that meaningful expenditure and price elasticities can be derived for each individual year. Next, the expenditure-elasticity estimates and three versions of own-price elasticity estimates (Cournot, Slutsky, and Frisch) will be calculated using the parameter estimates β_i^*s and π_{ij}^*s from Table 5-3 for each individual year from 1976 to 1987. In addition, estimated cross-price elasticities calculated at the sample means will also be presented and discussed.

Conditional Expenditure-Elasticity Estimates.

The estimated conditional expenditure elasticities of import demand for fresh grapefruit from country i can be obtained from

$$(5.3) \qquad \eta_{ii}^* = 1 + (\beta_i^* / \bar{w}_{ii}^*)$$

where β_i^*'s are the parameter estimates from Table 5-3 and $\bar{w}_{ii}^*$ are the observed arithmetic averages of the conditional import-expenditure share of product i from Table 5-1. The estimated conditional expenditure elasticities, calculated for each year from 1976 through 1987 and at the sample means, are reported in Table 5-4.

Table 5-4. Conditional Expenditure-Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community, 1976-87.

	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
1976	3.2955*** (.45361)[c]	.43564** (.21114)	.57613 (.52731)	.22883 (.23861)
1977	3.2861*** (.45176)	.44673** (.20699)	.69345** (.40056)	.10376 (.27731)
1978	3.6090*** (.51556)	.46823*** (.19895)	.67700** (.39621)	.12081 (.27203)
1979	3.3324*** (.46090)	.45355** (.20444)	.60635 (.49024)	.15535 (.26134)
1980	3.1129*** (.41753)	.42271** (.21598)	.59489 (.49693)	.19088 (.25035)
1981	2.9324*** (.38186)	.38876** (.22868)	.62672* (.47015)	.20634 (.24557)
1982	2.9123*** (.37790)	.36861* (.23622)	.66813** (.40709)	.21857 (.24178)
1983	2.7876*** (.35325)	.30887 (.25857)	.72442** (.33804)	.24872 (.23245)
1984	2.8300*** (.36163)	.28685 (.26681)	.76537*** (.28781)	.26338 (.22792)
1985	3.0865*** (.41232)	.31327 (.25692)	.75734*** (.29765)	.32444* (.20903)
1986	2.9123*** (.37789)	.31284 (.25708)	.71589** (.34851)	.30604* (.21472)
1987	2.6466*** (.32894)	.26867 (.27361)	.70877** (.35724)	.27703 (.22369)
At sample mean	3.0285*** (.40085)	.38034** (.23183)	.68430** (.38726)	.22542 (.23966)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.

[b] The rest of the world in the southern hemisphere.

[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

The results from Table 5-4 show that the conditional expenditure-elasticity estimates of import demand for fresh grapefruit from the U.S. are statistically greater than one at $\alpha = 0.01$, whereas the estimates from Israel-Cyprus and ROWN are statistically less than one at $\alpha = 0.05$. The conditional expenditure-elasticity estimates for ROWS are not significantly different from zero. Note that the conditional expenditure-elasticity estimates are useful when the analyst is interested in the effect of a change in the import volume of the commodity groups on a conditional expenditure share. Theil (1976) showed that an increase in import demand for group S_g raises the associated conditional import shares for those commodities that have conditional expenditure elasticities larger than one. The estimates in Table 5-4 show that this condition applies to fresh grapefruit from the U.S. only. That is, if the EC decided to increase its import demand for fresh grapefruit, only the conditional import share for fresh grapefruit from the U.S. would increase, at the expense of other suppliers. In other words, the U.S. would benefit the most from an increase of the import demand for fresh grapefruit in the EC.

In general, if the EC increases its total import expenditure for fresh grapefruit by one percent, there would be a 3.0-, 0.4-, and 0.7-percent increase in demand for fresh grapefruit imports from the U.S., Israel-Cyprus, and ROWN, respectively. These conditional expenditure-elasticity estimates indicate that fresh grapefruit from the U.S. is expenditure elastic, while those from Israel-Cyprus and ROWN are expenditure inelastic. One possible explanation for these results may be that consumers in the EC perceive fresh grapefruit from the U.S. as a superior product and are willing to pay a higher price for it (as shown

in Table 1-8). The estimated result also shows that changes in total import expenditure for fresh grapefruit as a group would have no impact on demand for fresh grapefruit imported from ROWS.

In addition, results from Table 5-4 show that, during the study period from 1976 through 1987, conditional expenditure-elasticity estimates of import demand for fresh grapefruit from the U.S. and Israel-Cyprus declined from 3.3 and 0.4 in 1976 to 2.6 and 0.3 in 1987, while those of ROWN and ROWS increased from 0.6 and 0.2 in 1976 to 0.7 and 0.3 in 1987, respectively. A gradual decrease in conditional expenditure-elasticity estimates for U.S. fresh grapefruit may be due to the fact that consumers in the EC have become more familiar with the product over the years. Since these elasticities were calculated using the observed-expenditure share, they reflect all of the factors that influence these expenditure shares, such as taste and relative prices. However, they do not exclusively reflect changes in total fresh grapefruit imports.

Conditional Price-Elasticity Estimates.

In the following section, three versions of own-price elasticities (Cournot, Slutsky, and Frisch), calculated for each individual year, will be presented and discussed. Conditional cross-price elasticity estimates at the sample means from each version will also be provided. These three versions of price elasticities represent the effects of changes in prices in different situations. The Cournot price elasticity (uncompensated price elasticity) refers to the situation where money expenditure remains constant, $d(\log E) = 0$. The Slutsky price elasticity (compensated price elasticity) refers to the situation where real expenditure remains constant, $d(\log Q) = 0$, in spite of the increase in the price of good i.

The Frisch price elasticity refers to the situation where there is an income compensation that keeps the marginal utility of expenditure constant.

Conditional Cournot price elasticity. The conditional Cournot price-elasticity estimates are the corresponding Slutsky elasticity estimates plus the expenditure effect of the change in the price of good j. Thus, holding total import expenditure on fresh grapefruit constant in money terms, as well as the other prices, the $(i,j)^{th}$ conditional Cournot price elasticities can be obtained using the following equations,

$$C^*_{ijt} = \pi^*_{ij}\sqrt{w^*_{it}} - \theta^*_i\overline{w}^*_{jt}/\overline{w}^*_{it} \quad \text{or} \tag{5.4}$$

$$C^*_{ijt} = S_{ijt} - \theta^*_i\overline{w}^*_{jt}/\overline{w}^*_{it} \,. \tag{5.5}$$

Conditional Cournot own-price elasticity estimates for each individual year are presented in Table 5-5. All conditional Cournot own-price elasticity estimates are negative and significantly different from zero, with the exception of ROWS, which is positive in sign. Over the period of 1976 through 1987, own-price elasticity estimates for fresh grapefruit from all four suppliers had been declining (in absolute value). In general, the conditional Cournot own-price elasticity estimates indicate that a one-percent increase (decrease) in the imported own price of fresh grapefruit from the U.S., Israel-Cyprus, and ROWN, would decrease (increase) import demand from the corresponding supplier by 1.2, 0.5, and 0.2 percent, respectively. These results indicate that imported fresh grapefruit from the U.S. is more responsive to price changes than those from Israel-Cyprus and ROWN. Unexpectedly, a one-percent increase in the import price of fresh grapefruit from ROWS would increase its corresponding import demand by 0.4 percent.

Table 5-5. Conditional Cournot Own-Price Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community, 1976-87.

Year	Exporting Country			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
1976	-1.2671*** (.35179)[c]	-.53781** (.27499)	-.23211** (.12925)	.42390* (.31254)
1977	-1.2657*** (.35028)	-.54229** (.27107)	-.20169** (.09609)	.52949* (.35988)
1978	-1.3206*** (.40239)	-.55220** (.26350)	-.20074** (.09483)	.51558* (.35342)
1979	-1.2731*** (.35772)	-.54525** (.26866)	-.22227** (.11950)	.48698* (.34034)
1980	-1.2395*** (.32252)	-.53312** (.27956)	-.22400** (.12125)	.45689* (.32689)
1981	-1.2155*** (.29379)	-.52314** (.29165)	-.21721** (.11423)	.44357* (.32105)
1982	-1.2131*** (.29062)	-.51867** (.29885)	-.20299** (.09778)	.43292* (.31643)
1983	-1.1994*** (.27097)	-.51074* (.32036)	-.19157*** (.08002)	.40622* (.30503)
1984	-1.2037*** (.27761)	-.50953* (.32833)	-.18773*** (.06735)	.39299* (.29950)
1985	-1.2357*** (.31831)	-.51108* (.31877)	-.18807*** (.06981)	.33592* (.27647)
1986	-1.2131*** (.29060)	-.51105* (.31892)	-.19292*** (.08269)	.35348* (.28340)
1987	-1.1884*** (.25169)	-.50913* (.33492)	-.19417** (.08492)	.38053* (.29435)
At sample mean	-1.2282*** (.30950)	-.52118** (.29461)	-.19910** (.09256)	.42645* (.31364)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

The conditional Cournot cross-price elasticity estimates are presented in Table 5-6. These estimates show strong complementary relationships between fresh grapefruit imports from the U.S. and ROWS, and between ROWN and ROWS. In addition, the cross-price elasticity estimates indicate that fresh grapefruit from the U.S. and ROWN are weak complements to each other. One possible explanation for these complementary relationships may be that there is a different producing season of fresh grapefruit in the northern and the southern hemispheres. Since fresh grapefruit from the U.S. and ROWN are available during the winter months, while fresh grapefruit from the southern hemisphere (ROWS) are available during the summer months, therefore, they should complement each other. The Cournot cross-price elasticity estimates between the U.S. and Israel-Cyprus indicates that they are independent of each other. All other cross-price elasticity estimates are relatively small and statistically not significant (see Wold and Jureen (1953) for criteria for interpretation of demand interrelationships).

Conditional Slutsky price elasticity. The $(i,j)^{th}$ conditional Slutsky price elasticities refer to the total substitution effect of a change in the price of fresh grapefruit from country i on import demand for fresh grapefruit from country j, given that total import demand for fresh fruits remain constant. The Slutsky price elasticities can be obtained by dividing the conditional Slutsky price-parameter estimates by the conditional average expenditure share,

$$S_{ijt} = \pi^{*}_{ijt}/\bar{w}^{*}_{it} \qquad (5.6)$$

where π^{*}_{ijt} are the Slutsky parameter estimates reported in Table 5-3, and the conditional averages of expenditure share, $\bar{w}^{*}_{it}$, are from Table 5-1.

Table 5-6. Conditional Cournot Price-Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community Estimated at the Sample Mean.

Exporting Country	Conditional Cournot Price Elasticity			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
U.S.	-1.2282***	-.78470**	-.10108*	-.91730***
	(.30950)[c]	(.46882)	(.07516)	(.22245)
Israel-Cyprus	.24001*	-.52118**	-.01364	-.08566
	(.16414)	(.29461)	(.04521)	(.13749)
ROWN	.24203	-.23131	-.19910**	-.49620**
	(.24012)	(.42319)	(.09256)	(.21988)
ROWS	-.38177**	-.12348	-.14714**	.42645*
	(.20500)	(.31300)	(.06699)	(.31364)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

The estimated conditional Slutsky own-price elasticities on a yearly basis are presented in Table 5-7. In addition, the conditional own-price and cross-price elasticity estimates at the sample means are presented in Table 5-8. All conditional Slutsky own-price elasticity estimates are statistically significant at $\alpha = 0.10$ and have the same sign as the Cournot own-price elasticity estimates. However, the conditional Slutsky own-price elasticity estimates are smaller (in absolute value) than the Cournot own-price elasticity estimates, except for ROWS, which is larger than its Cournot own-price elasticity. Unlike the estimated Cournot cross-price elasticity, the conditional Slutsky cross-price elasticity estimates between the U.S. and Israel-Cyprus and for the U.S. and ROWN are significantly positive. These results indicate that imported fresh grapefruit from the U.S. is a substitute for fresh grapefruit from Israel-Cyprus and ROWN, and vice versa. The results also show that the conditional Slutsky cross-price elasticity estimates between the U.S. and ROWS, and ROWN and ROWS are significantly negative. These results indicate that fresh grapefruit imports from ROWS is a complement of fresh grapefruit imports from the U.S. and ROWN, and vice versa.

Conditional Frisch price elasticity. Frisch price elasticities explain the situation when the marginal utility of expenditure is held constant. To calculate the conditional Frisch price elasticities in this model, one needs to obtain the own-price elasticity estimate of demand for imported fresh grapefruit as a group ($\phi\theta_g/\bar{W}_g$). One way to obtain the own-price elasticity of fresh grapefruit is to use the procedure suggested by Theil and Clements (1987).[1] Their procedure can be applied as follows.

[1] This procedure was also successfully used by Clements and Finke (1984), Clements and Johnson (1985), and Salvanathan (1985).

Table 5-7. Conditional Slutsky Own-Price Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community, 1976-87.

Year	Exporting Country			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
1976	-.57579* (.38069)[c]	-.30878* (.21567)	-.20022* (.14168)	.47162* (.29486)
1977	-.57344* (.37914)	-.30271* (.21143)	-.15210* (.10763)	.54811* (.34269)
1978	-.65443* (.43269)	-.29095* (.20321)	-.15024* (.10631)	.53768* (.33617)
1979	-.58505* (.38681)	-.29898* (.20882)	-.18615* (.13172)	.51655* (.32296)
1980	-.52999* (.35041)	-.31585* (.22061)	-.18869* (.13352)	.49483* (.30937)
1981	-.48471* (.32047)	-.33443* (.23358)	-.17852* (.12632)	.48537* (.30346)
1982	-.47969* (.31715)	-.34545* (.24128)	-.15457* (.10938)	.47790* (.29879)
1983	-.44840* (.29647)	-.37813* (.26411)	-.12836* (.09083)	.45945* (.28726)
1984	-.45903* (.30350)	-.39018* (.27253)	-.10928* (.07733)	.45049* (.28165)
1985	-.52337* (.34604)	-.37573* (.26243)	-.11302* (.07997)	.41315* (.25831)
1986	-.47967* (.31714)	-.37596* (.26259)	.13233* (.09364)	.42440* (.26534)
1987	-.41754* (.27606)	-.40013* (.27947)	-.13565* (.09598)	.44214* (.27644)
At sample mean	-.50951* (.33687)	-.33896* (.23675)	-.14691* (.10395)	.47339* (.29597)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.

[b] The rest of the world in the southern hemisphere.

[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

Table 5-8. Conditional Slutsky Price-Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community Calculated at the Sample Mean.

Exporting Country	Conditional Slutsky Price Elasticity			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
U. S.	-.50951* (.33687)[c]	.66708** (.36096)	.13002* (.08330)	-.28759* (.19033)
Israel-Cyprus	.33021** (.17808)	-.33896* (.23675)	.01537 (.05037)	-.00662 (.12397)
ROWN	.40433* (.25902)	.09656 (.31640)	-.14691* (.10395)	-.35399** (.19272)
ROWS	-.32821* (.21721)	-.01527 (.28581)	-.12991** (.07073)	.47339* (.29597)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

First, let the parameter DQ be the log change in total import expenditure for fresh fruit and DP^* be the log change in the price index of total fresh fruits. Then regress the log change from relative expenditure of fresh grapefruit, DQ_g - DQ, against its relative price, DP_g - DP^*, and obtain the least-square regression line. The slope of this line can be interpreted as an estimate of the own-price elasticity of demand for fresh grapefruit as a group, under the assumption of a unitary expenditure elasticity. Another way to obtain the own-price elasticity of fresh grapefruit as a group is by estimating a system of import demand for fresh fruits in the second stage and using the estimated own-price elasticity of fresh grapefruit directly. Since both the second- and third-stage budgets were estimated in this study, the Frisch own-price elasticity estimate for fresh grapefruit as a group from the second-stage budget, which is -0.3, will be used in the third stage. The conditional Frisch price elasticity can be obtained from

$$F_{ik} = v^*_{ik}/\bar{w}^*_k \tag{5.7}$$

where

$$v^*_{ik} = \pi^*_{ik} + (\phi\theta_g/\bar{W}_g)\ \theta^*_k\theta^*_{ik} .$$

v^*_{ik} are modified price coefficients and satisfy the following three conditions;

$$v^*_{ij} = v^*_{ji} \tag{5.8}$$

$$\sum_{i\in S_g} v^*_{ij} = (\phi\theta_g/\bar{W}_g)\ \theta^*_j , \qquad i \in S_g \tag{5.9}$$

$$\sum_{i\in S_g}\ \sum_{j\in S_g} v^*_{ij} = (\phi\theta_g/\bar{W}_g). \tag{5.10}$$

π^*_{ik} are the conditional Slutsky price coefficients from Table 5-3. The $\phi\theta_g/\overline{W}_g$ is the own-price elasticity of demand for fresh grapefruit as a group and was estimated to be -0.3; $\phi < 0$ is the income flexibility, θ_g is the marginal share of S_g, and $\theta^*_k = \beta^*_i + \overline{w}^*_k$.

Table 5-9 presents the Frisch conditional own-price elasticity estimates for import demand of fresh grapefruit from four sources on a yearly basis. The results in Table 5-9 indicate that all of the own-price elasticity estimates are negative and significantly different from zero except for ROWS, which is significantly positive. Over the years from 1976 through 1987, all conditional own-price elasticity estimates for the U.S., ROWN, and ROWS have been decreasing (in absolute value), while that for Israel-Cyprus has been increasing (in absolute value). These results indicate that, given a one-percent increase (decrease) in the imported own price of fresh grapefruit from the U.S., Israel-Cyprus, and ROWN, the import demand for fresh grapefruit from these suppliers would decrease (increase) by 1.1, 0.4 and 0.2 percent, respectively. However, the own-price elasticity estimate for ROWS, which has an unexpected positive sign, implies that a one-percent increase in the import price for fresh grapefruit from ROWS would increase its import demand by 0.5 percent. One can conclude from the results presented above that fresh grapefruit imports from the U.S. are more responsive to price changes than fresh grapefruit imports from the other three suppliers.

The Frisch cross-price elasticity estimates shown in Table 5-10 are similar to the Slutsky cross-price estimates. These results indicate that imported fresh grapefruit from the U.S. is a substitute for imported fresh grapefruit from Israel-Cyprus. On the other hand, fresh grapefruit imports from Israel-Cyprus are a substitute for fresh grapefruit imports

Table 5-9. Conditional Frisch Own-Price Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community, 1976-87.

Year	Exporting Country			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
1976	-1.1659*** (.34600)[c]	-.33462* (.22567)	-.20493* (.13747)	.46879* (.29658)
1977	-1.1664*** (.34623)	-.33043* (.22174)	-.16075* (.10279)	.54761* (.34345)
1978	-1.2771*** (.39324)	-.32263* (.21414)	-.15910* (.10146)	.53699* (.33706)
1979	-1.1789*** (.35155)	-.32791* (.21933)	-.19176* (.12731)	.51536* (.32411)
1980	-1.1020*** (.31854)	-.33964* (.23025)	-.19413* (.12914)	.49295* (.31080)
1981	-1.0397*** (.29145)	-.35343* (.24232)	-.18470* (.12182)	.48314* (.30501)
1982	-1.0329*** (.28845)	-.36199* (.24950)	-.16295* (.10457)	.47535* (.30042)
1983	-.99058*** (.26978)	-.38874* (.27085)	-.14022* (.08575)	.45603* (.28913)
1984	-1.0049*** (.27612)	-.39905* (.27874)	-.12483** (.07211)	.44716* (.28398)
1985	-1.0928*** (.31458)	-.38671* (.26927)	-.12774** (.07477)	.40666* (.26079)
1986	-1.0328*** (.28844)	-.38691* (.26942)	-.14356* (.08859)	.41878* (.26767)
1987	-.94954*** (.25141)	-.40771* (.28525)	-.14639* (.09097)	.43772* (.27853)
At sample mean	-1.0737*** (.30628)	-.35691* (.24527)	-.15616* (.09906)	.47064* (.29766)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.

[b] The rest of the world in the southern hemisphere.

[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

Table 5-10. Conditional Frisch Price-Elasticity Estimates of Import Demand for Fresh Grapefruit in the European Community Estimated at the Sample Mean.

Exporting Country	Conditional Frisch Price Elasticity			
	U.S.	Israel-Cyprus	ROWN[a]	ROWS[b]
U. S.	-1.0737*** (.30628)[c]	.52401* (.33909)	.08905 (.07621)	-.32444** (.18160)
Israel-Cyprus	.25939* (.16785)	-.35691* (.24527)	.01023 (.05011)	-.01125 (.12460)
ROWN	.27691 (.23700)	.06425 (.31480)	-.15616* (.09906)	-.36231** (.19076)
ROWS	-.37026** (.20725)	-.02593 (.28727)	-.13297** (.07001)	.47064* (.29766)

[a] The rest of the world in the northern hemisphere excluding the U.S. and Israel-Cyprus.
[b] The rest of the world in the southern hemisphere.
[c] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

from the U.S. This result indicates that, given a one-percent increase in the import price of fresh grapefruit from Israel-Cyprus, the import demand for fresh grapefruit from the U.S. would increase by 0.5 percent. Similarly, a one-percent increase in the import price of fresh grapefruit from the U.S. would increase the import demand from Israel-Cyprus by 0.3 percent. Similarly to the Cournot and Slutsky cross-price elasticity estimates, conditional Frisch cross-price elasticity estimates show a strong complementary relationship between fresh grapefruit imports from the U.S. and ROWN, and fresh grapefruit imports from ROWS.

The EC Import Demand for Fresh Fruits

In order to have a thorough understanding of import demand for fresh grapefruit from different suppliers in the EC, a knowledge of how fresh grapefruit as a group competes with all other fresh fruits in the EC markets is necessary. Consequently, an estimation of conditional import demand for four groups of fresh fruits in the EC, including fresh grapefruit as one group, was carried out. The rest of this chapter contains the empirical results of EC import demand for four groups of fresh fruits from the second-stage budget. The conditional expenditure-elasticity estimates and three versions of the conditional price-elasticity estimates (Cournot, Slutsky, and Frisch) will be presented and discussed.

Equation (4.29) will be used to estimate a system of conditional import demands for four groups of fresh fruits in the EC, defined earlier. This equation can be reintroduced here as

$$(5.11) \qquad \bar{W}_{gt} \, (DQ_{gt} - DQ_t) = B_g \, DQ_t + \sum_{h \in F_1} \Pi_{gh} \, DP_{ht}^{*}.$$

Dependent variables used in the analysis of equation (5.11) are the conditional budget shares of fresh fruits in group S_g, $\bar{W}_{gt}$, times the difference between the quantity log change from fresh fruits group S_g and the weighted sum of the quantity log change, $DQ_{gt} - DQ_t$. The independent variables used in the analysis are the weighted sum of the quantity log change DQ_t, and the price log change, DP_{ht}^{*}. The subscript g represents the kinds of fresh fruit or groups of fresh fruits imported into the EC where g = 1 refers to fresh grapefruit, g = 2 refers to fresh oranges, g = 3 refers to other citrus fruits, and g = 4 refers to other fresh fruits. The subscript h refers to the h^{th} group of fresh fruits; F_1 refers to the imported fresh fruits group as a whole; and t represents time period (year).

Results for Fresh Fruits Import Demand

Equation (5.11) was fitted to the system of four conditional import-demand equations for fresh fruits using iterative, seemingly unrelated regressions (SUR) with the Slutsky symmetry and adding-up restrictions imposed. Results of the estimated import-demand system for fresh grapefruit, fresh oranges, other fresh citrus, and other fresh fruits are presented in Table 5-11. Parameter estimates of the conditional expenditure shares are negative for fresh grapefruit and other fresh fruits, and positive for fresh oranges and other fresh citrus; all are significantly different from zero at the $\alpha = 0.01$. All own-price coefficients are negative except that for fresh oranges, which is

Table 5-11. Parameter Estimates of Conditional Import-Demand Equations for Fresh Fruits in the European Community Estimated at the Sample Mean.

Fresh Fruit Import	Expenditure Coefficient (B_g)	Modified Slutsky Coefficient (Π_{gh})			
		Grape-Fruit	Oranges	Other citrus	Other fruits
Grape-fruit	-.07802*** (.01624)[a]	-.01501 (.01972)	.00663 (.01367)	-.00307 (.00544)	.01144 (.01663)
Oranges	.29887*** (.09446)		.00032 (.06971)	.00322 (.01427)	-.01017 (.07304)
Other citrus	.08373*** (.02149)			-.00282 (.00481)	.00266 (.01590)
Other fruits	-.30459*** (.10264)				-.00393 (.07968)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

positive. The parameter estimates from Table 5-11 will be used to calculate the conditional expenditure-elasticity estimates and three versions of conditional price-elasticity estimates (Cournot, Slutsky, and Frisch) for imported fresh fruits.

Conditional Expenditure-Elasticity Estimates.

In this study, the conditional expenditure elasticities of import demand for each group of fresh fruits can be obtained from

$$N_{gt} = 1 + (B_g / \bar{W}_{gt}), \tag{5.12}$$

where B_g are the expenditure coefficients from Table 5-11, and $\bar{W}_{gt}$ are the observed arithmetic averages of the conditional budget shares of fresh fruits in group g. The conditional expenditure-elasticity estimates, evaluated at the sample means and for each year from 1976 to 1987, are reported in Table 5-12. These estimates are useful when the analyst is interested in the effect of a change in the import volume of the commodity groups on a conditional expenditure share.

The results from Table 5-12 indicate that import demand for fresh oranges and other fresh citrus in the EC is expenditure elastic. In general, given a one-percent increase in the EC's import expenditure for total fresh fruits, there would be a 2.0- and 3.0-percent increase in import demand for fresh oranges and other fresh citrus, respectively. The conditional expenditure-elasticity estimates for other fresh fruits were shown to be expenditure inelastic. A one-percent increase in import expenditure for total fresh fruits would result in a 0.5-percent increase in import demand for other fresh fruits. These results imply that, if the

Table 5-12. Conditional Expenditure-Elasticity Estimates of Import Demand for Fresh Fruits in the European Community, 1976-87.

Year	Grapefruit	Oranges	Other citrus	Other fruits
1976	-.29465 (.26956)[a]	1.8507*** (.26886)	3.0367*** (.52283)	.44347*** (.18754)
1977	-.37110* (.28548)	1.8358*** (.26502)	3.2040*** (.56577)	.44488*** (.18706)
1978	-.43622* (.29903)	1.8658*** (.27365)	3.1485*** (.55084)	.45752*** (.18280)
1979	-.33360 (.27767)	1.8728*** (.27585)	2.9121*** (.49083)	.45147*** (.18484)
1980	-.27040 (.26451)	1.8791*** (.27785)	2.7546*** (.45041)	.44711*** (.18631)
1981	-.21785 (.25357)	1.9943*** (.31426)	2.6646*** (.42731)	.47939*** (.17543)
1982	-.25872 (.26208)	2.0423*** (.32943)	2.8782*** (.48214)	.49796*** (.16917)
1983	-.37496* (.28628)	1.9723*** (.30730)	3.0210*** (.51879)	.48762*** (.17266)
1984	-.47144* (.30637)	1.9818*** (.31031)	3.0065*** (.51506)	.49307*** (.17082)
1985	-.50232* (.31280)	2.0573*** (.33417)	2.9293*** (.49524)	.51031*** (.16501)
1986	-.24805 (.25986)	2.4260*** (.45071)	3.3559*** (.60477)	.56008*** (.14824)
1987	-.15163 (.24072)	3.1156*** (.66865)	5.5162*** (1.1593)	.60583*** (.13283)
At sample mean	-.32028 (.27490)	2.0052*** (.31770)	3.0410*** (.53163)	.49501*** (.17017)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

EC allocates more of its import expenditure for imported fresh fruits, most of the increase will be allocated to other fresh citrus and fresh oranges; the rest will be allocated to other fresh fruits. Unexpectedly, expenditure-elasticity estimates for fresh grapefruit are negative. However, they are not statistically different from zero, which means that import demand for fresh grapefruit would not increase as a result of an increase in import expenditure allocated to fresh fruits as a group. The findings from both the second- and the third-stages in this study imply that the expenditure share for imported fresh grapefruit would not be affected when total expenditure for fresh fruits changes. Only when import expenditure for fresh grapefruit as a group increases can the U.S. increase its market share for fresh grapefruit in the EC. In other words, import demand for fresh grapefruit in the EC from a particular supplier can not be increased through an increase in total import demand, but rather through an increase in market share.

Conditional Price-Elasticity Estimates.

The following section presents and discusses three versions of price-elasticity estimates (Cournot, Slutsky, and Frisch). Conditional own-price elasticities will be calculated for each year from 1976 to 1987, whereas cross-price elasticities will only be calculated at the sample means. Even though all three versions of price elasticities are presented, the conditional Cournot price elasticity should be used as a tool for marketing purposes

Conditional Cournot price elasticity. Conditional Cournot own-price elasticity estimates for each year from 1976 through 1987 are presented

in Table 5-13. The results of own-price and cross-price elasticities, estimated at the sample means, are presented in Table 5-14. The own-price elasticity estimates indicate that fresh oranges, other fresh citrus, and other fresh fruits are price inelastic. In general, a one-percent increase (decrease) in total import expenditure for fresh fruits would result in a 0.6-, 0.2-, and 0.3-percent decrease (increase) in import demand for fresh oranges, other fresh citrus, and other fresh fruits, respectively. Own-price elasticity estimates for fresh grapefruit are negative but significantly not different from zero. During 1976 through 1987, the own-price elasticity estimates for fresh oranges have been decreasing over time from -0.6 in 1976 to -0.4 in 1987, while those of other citrus and other fresh fruits have been increasing from -0.2 and -0.2 in 1976 to -0.3 and -0.5 in 1987. During this same period, the own-price elasticity estimates for fresh grapefruit are relatively stable around -0.2. Negative cross-price elasticity estimates shown in Table 5-14 indicate that imported fresh oranges and other fresh citrus are strong complements for each other. The estimates between other fresh citrus and fresh grapefruit, fresh oranges and fresh grapefruit, other fresh fruits and fresh oranges, and other fresh fruit and other fresh citrus were shown to have a weak complementary relationship (for definitions of substitution and complementary relationships, see Wold and Jureen (1953)).

Conditional Slutsky price elasticity. The conditional Slutsky own-price elasticity estimates of fresh fruits for each year from 1976 through 1987 and at the sample means are presented in Table 5-15. All of the conditional own-price elasticity estimates are negative, with the exception of fresh oranges. The conditional cross-price elasticity

Table 5-13. Conditional Cournot Own-Price Elasticity Estimates of Import Demand for Fresh Fruits in the European Community, 1976-87.

Year	Grapefruit	Oranges	Other citrus	Other fruits
1976	-.23124 (.32856)[a]	-.64931*** (.23255)	-.19334* (.11901)	-.24988* (.16622)
1977	-.24258 (.34786)	-.65442*** (.22996)	-.19584* (.12849)	-.25125* (.16593)
1978	-.25253 (.36431)	-.64315*** (.23579)	-.19492* (.12519)	-.26388* (.16333)
1979	-.23697 (.33839)	-.64038*** (.23729)	-.19182** (.11197)	-.25776* (.16457)
1980	-.22773 (.32243)	-.63791*** (.23864)	-.19046** (.10310)	-.25344* (.16547)
1981	-.22027 (.30917)	-.59840** (.26358)	-.19001** (.09805)	-.28718** (.15889)
1982	-.22605 (.31948)	-.58451** (.27408)	-.19148** (.11006)	-.30858** (.15519)
1983	-.24317 (.34884)	-.60523*** (.25878)	-.19313* (.11813)	-.29647** (.15724)
1984	-.25800 (.37320)	-.60224** (.26086)	-.19294** (.11730)	-.30279** (.15616)
1985	-.26285 (.38101)	-.58042** (.27737)	-.19201** (.11294)	-.32373** (.15276)
1986	-.22453 (.31679)	-.50694* (.35953)	-.19850* (.13711)	-.39345*** (.14331)
1987	-.21182 (.29358)	-.43791 (.51654)	-.25415 (.26051)	-.47322*** (.13514)
At sample mean	-.23500 (.33503)	-.59514** (.26595)	-.19381* (.12095)	-.30507** (.15577)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

Table 5-14. Conditional Cournot Price-Elasticity Estimates of Import Demand for Fresh Fruits in the European Community Estimated at the Sample Mean.

Fresh Fruits Import	Conditional Cournot Price Elasticity			
	Grapefruit	Oranges	Other citrus	Other fruits
Grapefruit	-.23500 (.33503)[a]	.20748 (.25732)	-.03893 (.09176)	.38674 (.30263)
Oranges	-.09618** (.04839)	-.59514** (.26595)	-.07023* (.05045)	-1.2436*** (.28864)
Other citrus	-.25729** (.13794)	-.83340** (.40541)	-.19381* (.12095)	-1.7865*** (.47817)
Other fruits	-.01029 (.02897)	-.16404 (.13779)	-.01560 (.02770)	-.30507** (.15577)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

Table 5-15. Conditional Slutsky Own-Price Elasticity Estimates of Import Demand for Fresh Fruits in the European Community, 1976-87.

Year	Grapefruit	Oranges	Other citrus	Other fruits
1976	-.24900 (.32731)[a]	.00090 (.19841)	-.06850 (.11711)	-.00717 (.14560)
1977	-.26370 (.34664)	.00089 (.19558)	-.07412 (.12673)	-.00716 (.14523)
1978	-.27623 (.36311)	.00091 (.20195)	-.07217 (.12338)	-.00699 (.14192)
1979	-.25649 (.33716)	.00092 (.20357)	-.06431 (.10994)	-.00707 (.14350)
1980	-.24433 (.32118)	.00093 (.20505)	-.05901 (.10089)	-.00713 (.14464)
1981	-.23423 (.30790)	.00105 (.23192)	-.05598 (.09571)	-.00671 (.13620)
1982	-.24209 (.31823)	.00110 (.24311)	-.06317 (.10800)	-.00647 (.13134)
1983	-.26444 (.34762)	.00103 (.22678)	-.06797 (.11621)	-.00660 (.13405)
1984	-.28300 (.37201)	.00104 (.22900)	-.06748 (.11537)	-.00653 (.13262)
1985	-.28894 (.37982)	.00112 (.24661)	-.06488 (.11093)	-.00631 (.12811)
1986	-.24003 (.31553)	.00151 (.33262)	-.07923 (.13547)	-.00567 (.11509)
1987	-.22236 (.29229)	.00223 (.49345)	-.15188 (.25968)	-.50806 (.10312)
At sample mean	-.25393 (.33380)	.00106 (.23445)	-.06965 (.11908)	-.00651 (.13211)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

Table 5-16. Conditional Slutsky Price-Elasticity Estimates of Import Demand for Fresh Fruits in the European Community Calculated at the Sample Mean.

Fresh Fruits Import	Conditional Slutsky Price Elasticity			
	Grapefruit	Oranges	Other citrus	Other fruits
Grapefruit	-.25393 (.33380)[a]	.11225 (.23127)	-.05188 (.09214)	.19356 (.28147)
Oranges	.02231 (.04596)	.00106 (.23445)	.01084 (.04800)	-.03421 (.24567)
Other citrus	-.07583 (.13466)	.07970 (.35300)	-.06965 (.11908)	.06578 (.39322)
Other fruits	.01896 (.02758)	-.01686 (.12110)	.00441 (.02636)	-.00651 (.13211)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

estimated at the sample means are presented in Table 5-16. However, all of the Slutsky price elasticity estimates are statistically not different from zero.

Conditional Frisch price elasticity. In order to calculate conditional Frisch price elasticities, it is necessary to obtain the own-price elasticity of import demand for total fresh fruits as a group. This own-price elasticity of import demand for total fresh fruits as a group can be obtained from the estimation of import demand for all imported goods in the first-stage budget allocation. However, since the first-stage import demand was not estimated in this study due to the limitation of data, an approximation of -0.78 will be used. This approximation of the own-price elasticity estimate of import demand for fresh fruits as a group is based on the median value of the best estimate of import demand for food, beverages, and tobacco (Stern et al. 1976).

Frisch price-elasticity estimates represent the price elasticity when the marginal utilities of expenditure are held constant. Conditional own-price elasticity estimates of import demand for the four groups of fresh fruits are reported in Table 5-17 on a year-by-year basis. All of the conditional own-price elasticity estimates are negative. However, only the estimates of fresh oranges and other fresh citrus are statistically significant. The point estimates of the conditional own-price elasticities in Table 5-17 indicate that fresh oranges are unitary price elastic, while other fresh citrus are price inelastic. In general, a one-percent increase (decrease) in the own price of imported fresh oranges and other citrus would result in a 1.0- and 0.4-percent decrease (increase) in import demand for fresh oranges and other fresh citrus, respectively. The estimates for own-price elasticity of fresh grapefruit

Table 5-17. Conditional Frisch Own-Price Elasticity Estimates of Import Demand for Fresh Fruits in the European Community, 1976-87.

Year	Grapefruit	Oranges	Other citrus	Other fruits
1976	-.25347 (.32699)[a]	-1.0279*** (.38347)	-.39263*** (.16158)	-.09920 (.15538)
1977	-.27040 (.34626)	-1.0292*** (.37998)	-.40756*** (.17278)	-.10000 (.15516)
1978	-.28506 (.36268)	-1.0265*** (.38783)	-.40232*** (.16888)	-.10748 (.15317)
1979	-.26205 (.33681)	-1.0260*** (.38984)	-.38181*** (.15325)	-.10384 (.15411)
1980	-.24817 (.32088)	-1.0255*** (.39166)	-.36860*** (.14275)	-.10129 (.15480)
1981	-.23683 (.30764)	-1.0211*** (.42501)	-.36133*** (.13677)	-.12167 (.14994)
1982	-.24563 (.31794)	-1.0215*** (.43898)	-.37892*** (.15098)	-.13509 (.14743)
1983	-.27126 (.34724)	-1.0213*** (.41861)	-.39254*** (.16151)	-.12745 (.14880)
1984	-.29307 (.37156)	-1.0212*** (.42138)	-.38998*** (.15955)	-.13143 (.14807)
1985	-.30014 (.37935)	-1.0218** (.44336)	-.38328*** (.15439)	-.14481 (.14589)
1986	-.24332 (.31525)	-1.0532** (.55178)	-.42146** (.18298)	-.19136* (.14072)
1987	-.22376 (.29210)	-1.1702* (.75728)	-.63422** (.32905)	-.24757** (.13758)
At sample mean	-.25911 (.33345)	-1.0211*** (.42817)	-.39565*** (.16387)	-.13287 (.14782)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

and other fruits in the EC indicated that import demand for these products as a group do not respond to changes in their own price. Since these conditional own-price elasticities were calculated using the observed budget share, they reflect all of the factors that influence these budget shares, such as taste and relative prices. However, they do not exclusively reflect changes in total fresh fruits imports.

As shown in Table 5-18, the positive cross-price elasticity estimate indicates that fresh grapefruit is a weak substitute for other fresh fruits. This estimate indicates that, if the price of other fresh fruits increased by one percent, there would be a 0.3-percent increase in import demand for fresh grapefruit. On the other hand, changes in the import price of fresh grapefruit would have no impact on import demand for other fresh fruits. The negative conditional cross-price elasticity estimates between fresh oranges and other fresh citrus, fresh oranges and other fresh fruits, and between other fresh citrus and other fresh fruits suggest that they are complements.

Discussion

This study has shown that both import expenditure and own-price elasticity estimates of fresh grapefruit in the second-stage allocation are not significantly different from zero. It also indicated that total import demand for fresh grapefruit in the EC is not likely to increase in the near future. However, the elasticity estimates from the third-stage allocation indicated that it is possible for fresh grapefruit from different suppliers to compete for market shares in the EC. These results suggested that the most promising U.S. marketing strategy to handle the future increase in supply of fresh colored grapefruit would be to expand

Table 5-18. Conditional Frisch Price-Elasticity Estimates of Import Demand for Fresh Fruits in the European Community Calculated at the Sample Mean.

Fresh Fruits Import	Conditional Frisch Price Elasticity			
	Grapefruit	Oranges	Other citrus	Other fruits
Grapefruit	-.25911 (.33345)[a]	.27552 (.29809)	-.01788 (.09498)	.31070* (.27915)
Oranges	.05476 (.05924)	-1.0211*** (.42817)	-.20203*** (.08473)	-.54608** (.27657)
Other Citrus	-.02613 (.13882)	-1.4857*** (.62314)	-.39565*** (.16387)	-.71816* (.43746)
Other fruits	.02697 (.02728)	-.26919** (.13634)	-.04814* (.02932)	-.13287 (.14782)

[a] Asymptotic standard errors are shown in parentheses below the parameter estimates.

* Indicates statistically significant at the $\alpha = 0.10$ level.
** Indicates statistically significant at the $\alpha = 0.05$ level.
***Indicates statistically significant at the $\alpha = 0.01$ level.

the market share in the EC. One way for the U.S. to expand its market share of fresh grapefruit exports to the EC is to decrease the price. Since fresh grapefruit from the U.S. is price elastic, the U.S. could increase its export revenue from fresh grapefruit by decreasing price. The percentage change in the quantity of fresh grapefruit imports demanded in the EC can be obtained from $dQ_i = \Sigma_j (\partial q_i/\partial p_j)(p_j/q_i)\ dp_j)$, using the estimated price elasticities. For example, if global prices of fresh grapefruit in the EC remain the same and the U.S. decides to decrease its own price by one percent, then there would be a 1.2-percent increase in import demand for U.S. fresh grapefruit. However, if import prices of fresh grapefruit from all suppliers decrease by one percent due to a global increase in supply of fresh grapefruit in the market, then there would be a 3.0-, 0.4-, 0.7- and 0.2-percent increase in import demand for fresh grapefruit from the U.S., Israel-Cyprus, ROWN, and ROWS, respectively. On the other hand, if all suppliers increase their prices proportionally, then the U.S. would be more disadvantaged than other suppliers. The above discussion indicated that, among all four groups of suppliers, the U.S. would benefit the most when imported prices decrease or the supplies of fresh grapefruit increase. Note that this analysis is based on the conditional Cournot price-elasticity estimates, which assume that money expenditure remains constant when prices change. Another marketing strategy that could be used to increase market share for U.S. fresh grapefruit in the EC is the promotional program. Since the goal of this program is to gain market share, therefore, the U.S. would be more benefitted by promoting U.S. fresh grapefruit and not the whole category (generic). Promotion of U.S. grapefruit can help persuade consumers to switch to U.S. fresh grapefruit. In addition, the expenditure-elasticity

estimates indicated that, if the EC decided to allocate more import expenditure to the fresh grapefruit category, a larger portion of the increase will be allocated to U.S. fresh grapefruit than to other suppliers.

In the next chapter, a brief summary of the research and empirical results of import demand for fresh fruits and fresh grapefruit in the EC will be presented. Implications and suggestions for future research will also be provided.

CHAPTER 6
SUMMARY AND IMPLICATIONS

In this chapter, the research and empirical results of import demand for fresh fruits and fresh grapefruit in the EC will be summarized. Implications and suggestion for future research will also be provided.

Summary

Even though the U.S. world production share of grapefruit has been on a decline, production of grapefruit in Florida, especially the colored seedless variety, has been increasing in the past decade. Despite the freezes in the early 1980s, Florida production of colored grapefruit almost doubled its production. Exports of fresh grapefruit have also increased over time. The export revenue shares for fresh grapefruit from Florida, among all fresh citrus exports, increased from 49 percent in the 1985-86 season to 52 percent in 1987-88 season.

The Florida colored grapefruit are mainly for domestic consumption and export to European countries in fresh form. In addition, there is a trend for Florida fresh grapefruit to shift away from domestic markets to export markets. The increase in exports of Florida fresh grapefruit came primarily from the demand in EC market. This increase is expected to continue in the future. Since the EC demand for fresh grapefruit has a direct effect on the economy of Florida's citrus industry, there has been a need for an investigation of factors which affect the demand for U.S. fresh grapefruit in the EC market. The focus of this analysis was placed

on the import demand for fresh grapefruit in the EC, which is one of the most important export markets for the U.S. colored variety fresh grapefruit.

The objectives of this study were:

(1) to develop a theoretical import-demand model for fresh fruits and fresh grapefruit in the EC countries based on international trade theory;

(2) to investigate the factors affecting the import demand for four groups of fresh fruits in the EC markets;

(3) to investigate the factors affecting the import demand for fresh grapefruit from four groups of suppliers in the EC markets; and

(4) to analyze the implications from the estimated import-demand model and provide information to help formulate long-run trade strategies of U.S. fresh grapefruit exports to the EC.

In light of the above objectives, a modified Rotterdam/Working's model, which is an allocation model derived from the differential approach, was developed. The advantage of the modified Rotterdam/Working's model is that expenditure and price elasticities can be derived for each individual time period. This modified Rotterdam/Working's model was applied to a three-stage budgeting import-demand system under the assumption of block independence. Due to the lack of data, no attempt was made to carry out an estimation of import demand for all imported goods in the first-stage allocation. In the second-stage allocation, import expenditure on fresh fruits is allocated among four groups of imported fresh fruits under the block-independent assumption. These four groups of imported fresh fruits are (1) fresh grapefruit, (2) fresh oranges, (3) other fresh citrus excluding fresh grapefruit and fresh oranges, and (4) other fresh fruits excluding fresh citrus. In the third-stage allocation, import expenditure for fresh grapefruit was further

allocated to different suppliers. The groups of suppliers of fresh grapefruit considered in the third-stage allocation are (1) the U.S., (2) Israel-Cyprus, (3) the rest of the world in the northern hemisphere except the U.S. and Israel-Cyprus (ROWN), and (4) the rest of the world in the southern hemisphere (ROWS). The second- and the third-stage allocations were estimated using iterative seemingly unrelated regression (SUR) with Slutsky symmetry and adding-up restriction imposed.

The data employed in this study were provided by the Statistical Office of the European Community (Eurostat) and the Economics and Statistics Department of the Organization for Economics Cooperation and Development (OECD). These data consist of 13 annual observations from 1975 through 1987. The statistical results, interpretation of import-expenditure elasticities, and three versions of price elasticities (Frisch, Slutsky, and Cournot) for import demand for fresh grapefruit and import demand for fresh fruits in the EC were presented in Chapter 5. Summary of results and conclusions will be presented in the following section.

Import Demand for Fresh Grapefruit: Third-stage Allocation

The estimated results for import demand for fresh grapefruit among four suppliers indicate that the conditional import-expenditure-elasticity estimates are statistically greater than one for the U.S. and less than one for Israel-Cyprus and ROWN. In other words, if the EC increases its import expenditure for fresh grapefruit, holding all imported prices constant, the supplier that benefits the most would be the U.S. The expenditure-elasticity estimates indicate that, if the EC increased its total import expenditure for fresh grapefruit by one percent, there would

be a 3.0-, 0.4-, and 0.7-percent increase in fresh grapefruit imports from the U.S., Israel-Cyprus, and ROWN, respectively. However, the change in total import expenditure for fresh grapefruit shows no impact on import demand for fresh grapefruit from ROWS.

The empirical findings in this study indicate that, in general, import demands for fresh grapefruit are negatively related to their own price, except for ROWS, which is unexpectedly positive. The own-price elasticity estimate for fresh grapefruit imports from the U.S. was shown to be unitary price elastic, while those from Israel-Cyprus and ROWN were shown to be price inelastic. Conditional cross-price elasticity estimates indicate that fresh grapefruit from the U.S. and Israel-Cyprus are substitutes for each other. The results also show that fresh grapefruit imports from the U.S. and ROWN are complements to fresh grapefruit imports from ROWS, and vice versa. Since Florida's grapefruit season extends across the winter and spring months (November through May), one expects that its main competition in the export market comes from Israel and Cyprus, where grapefruit has the same production season. Therefore, the principal competitors for Florida's fresh grapefruit in the EC markets are Israel and Cyprus. In addition, grapefruit from Israel-Cyprus enjoys a preferential tariff and considerable price advantage over Florida in the EC market. Based upon import data in the past decades, Florida fresh grapefruit prices average 46 percent higher than its Mediterranean competitors' prices. Since fresh grapefruit from the northern hemisphere (the U.S. and ROWN) and fresh grapefruit from the southern hemisphere are available and exported to the EC during different times of the year, therefore, they should be complementary to each other. Moreover, price-elasticity estimates of import demand for fresh grapefruit in the EC also

show that if import prices of fresh grapefruit in the EC change (increase or decrease) proportionally across all suppliers (e.g., due to changes in the global grapefruit supply), there would be a greater impact on the U.S. than on other suppliers. For example, the analysis shows that if there is a one-percent decrease (increase) in import prices of fresh grapefruit from all four suppliers holding import expenditure constant, there would be a 0.78-, 0.19-, 0.17-, and 0.06-percent increase (decrease) in import demand for grapefruit from the U.S. Israel-Cyprus, ROWN, and ROWS, respectively.

Import Demand for Fresh Fruits: Second-stage Allocation

The results from the second-stage allocation show that import demands for fresh oranges and other fresh citrus in the EC are expenditure elastic. Given a one-percent increase (decrease) in import demand for fresh fruits as a group, there would be a 2.0-, 3.0-, and 0.5-percent increase (decrease) in import demand for fresh oranges, other fresh citrus, and other fresh fruits, respectively. The estimates for fresh grapefruit indicate that the imports of fresh grapefruit are not significantly affected by the group expenditures for all fresh fruits.

In general, the conditional own-price elasticity estimates show that all four groups of fresh fruits imported into the EC were negatively related to their own prices. Import prices of fresh oranges and other fresh citrus were found to be unitary price elastic and price inelastic, respectively. The own-price elasticity estimates for imported fresh grapefruit in the EC are statistically not different from zero. A positive cross-price elasticity estimate was found between fresh grapefruit and other fresh fruits, which indicates that fresh grapefruit

is a substitute for other fresh fruits. The cross-price elasticity estimates between fresh oranges and other fresh citrus, fresh oranges and other fresh fruits, and other fresh citrus and other fresh fruits are negative, suggesting complementary relationships among these fruit groups.

Implications

This study constitutes one of the first attempts to study the import demand for fresh grapefruit and fresh fruits in the EC countries. A study of import demand for fresh fruits and fresh grapefruit in the EC may be helpful in assisting the U.S., particularly the Florida citrus industry, to formulate trade strategies, such as pricing strategies, marketing strategies, and promotional and advertising programs for Florida grapefruit in the EC market.

The findings in this study indicated that competition for import shares of fresh grapefruit occurs among supplying regions of fresh grapefruit. Additionally, results also indicated that import demand for fresh grapefruit, as a group, is independent of the EC's group import expenditure for fresh fruits. Changes in import prices of fresh grapefruit in the EC were shown to have a considerable impact on the import demand for fresh grapefruit from the U.S. This suggested that the depreciation of the U.S. dollar in the past decade, which contributed to lower prices of U.S. fruit in the EC, may be one of the factors that led to an increased U.S. import share of fresh grapefruit in the EC market. Even though grapefruit in Florida was affected by the freeze in winter 1989, the production of fresh grapefruit is still expected to increase in the long run.

Since the current import demand for fresh grapefruit in the EC is relatively constant, an increase in global supply may lead to decreased prices of fresh grapefruit, which will benefit the U.S. more than other suppliers. The findings in this study indicated that, if production of grapefruit in the U.S. increased and import demand for fresh grapefruit in the EC increased, then the U.S. would benefit the most. However, the impact on import demand for fresh grapefruit in the EC as a result of unification of the EC in 1992 (project EC-92) and the consolidation of East Germany and West Germany is still uncertain.

Suggestions for Future Research

To obtain better estimates of the EC import demand for U.S. fresh grapefruit, some suggestions for future research are offered. Since the expansion of the EC by including Spain, Greece, and Portugal has a direct impact on import demand for fresh grapefruit in the EC, future research should take into account the internal trade of fresh grapefruit among the EC countries. In addition, unification of the EC in 1992 may have some impacts on exporting regions of fresh grapefruit, especially the U.S. Therefore, trade agreements should be considered in the analysis.

During the past decade, the Florida citrus industry had promoted fresh grapefruit heavily in the EC. This promotional effort should influence the import demand for fresh grapefruit in the EC. Due to the lack of information on promotional expenditures from other suppliers, the impacts of these programs were not included in the current study. However, further research should examine the possibility of including the impacts of promotional programs on the import demand for fresh grapefruit.

In the future, when data become available, the test of separability between domestic and imported fresh grapefruit in the EC, and fresh grapefruit and other fresh fruits could be carried out. Further, an extension of the modified Rotterdam/Working's model, used in this study, can be done by allowing Π_{ij} to vary.

APPENDIX

APPENDIX
BARTEN'S FUNDAMENTAL MATRIX EQUATION

Let $p = [p_1, \ldots, p_n]'$ and $q = [q_1, \ldots, q_n]'$ be the price and quantity vectors of n goods, respectively, and E be the total expenditure on n goods. The budget constraint can be written as:

$$\text{(A.1)} \qquad \Sigma_i \, p_i q_i = E \quad \text{or} \quad p'q = E$$

where $E > 0$ and $p_i > 0$ for all i. The utility function is denoted as $u = u(q)$. This utility function is assumed to be strictly increasing, strictly quasi-concave, and twice continuously differentiable. The first-order derivatives of the utility function,

$$\text{(A.2)} \qquad u_i = \partial u / \partial q_i, \qquad i = 1, \ldots, n,$$

are interpreted as marginal utilities and are assumed to be positive for all i. These marginal utilities of n goods show the increment to total utility that occurs as a result of consuming an additional amount of the commodity per unit of time. The second-order derivatives of the utility function (the Hessian matrix of the utility function),

$$\text{(A.3)} \qquad U = u_{ij} = \partial^2 u / \partial q_i \partial q_j \qquad i,j = 1, \ldots, n,$$

are symmetric negative definite because of the continuity and differentiability assumptions. The strict quasi-concavity assumption implies that the marginal rate of substitution is diminishing. These

second-order derivatives describe the rates of change of the first derivatives and thus the behavior of the marginal utility for each of the commodities.

To maximize u(q) subject to the budget constraint (A.1), one can introduce the Lagrangian function

(A.4) $\quad u(q) - \lambda(p'q - E)$

where λ is a Lagrangian multiplier interpreted as the marginal utility of income. Differentiating the Lagrangian equation (A.4) with respect to each of the arguments, q_i and λ, and equating the derivative to zero, yields the first-order conditions of the constrained utility maximum

(A.5) $\quad \partial u/\partial q_i = \lambda p_i \qquad i = 1, \ldots, n,$ and

(A.6) $\quad p'q = E,$

which is the familiar proportionality of the marginal utilities of the n goods to the corresponding prices and the budget constraint, respectively. The i^{th} equation of (A.5) states that the marginal utility of good i equals λp_i. This can be seen by dividing both sides of (A.5) by p_i to obtain $(\partial u/\partial q_i)/p_i = \lambda$, which indicates that a one-dollar increase in income causes the utility level to rise by λ units when this increase is spent on any of the n goods. The second-order condition is satisfied by the assumption of a negative definite Hessian U.

Combining the system of equations (A.5) and (A.6) gives (n + 1) equations and n + 1 unknowns: the n quantities and the Lagrangian multiplier λ. In order to obtain Barten's fundamental matrix equation (Barten 1964), one must firstly differentiate (A.5) and (A.6) with respect

to income and all prices. The result can be written in the matrix form as

$$(A.7)\quad \begin{bmatrix} U & p \\ p' & 0 \end{bmatrix} \begin{bmatrix} \partial q/\partial E & \partial q/\partial p' \\ -\partial \lambda/\partial E & \partial \lambda/\partial p' \end{bmatrix} = \begin{bmatrix} 0 & \lambda I \\ 1 & -q' \end{bmatrix}$$

The first matrix, on the left, is the bordered Hessian where $U = [\partial^2 u/\partial q_i \partial q_j]$ is the Hessian matrix of the utility function bordered by prices. The second matrix, in the middle, contains the derivatives of all dependent variables with respect to all independent variables where $\partial q/\partial E$ and $\partial q/\partial p'$ are the matrix of derivatives of the vector demand system ($q = q^*(E, p)$), and $-\partial \lambda/\partial E$ and $\partial \lambda/\partial p'$ are derivatives of the marginal utility of income.

The next step is solving the matrix equation (A.7) to obtain the price derivatives of the demand system. Details on how to solve this matrix equation (A.7) can be found in Theil et al. (1989, pp. 158-160). The final result can be expressed as:

$$(A.8)\quad \partial q_i/\partial p_j = \lambda u^{ij} - (\lambda/(\partial \lambda/\partial E))(\partial q_i/\partial E)(\partial q_j/\partial E) - (\partial q_i/\partial E)q_j$$

or

$$\partial q_i/\partial p_j = \lambda u^{ij} - \phi E(\partial q_i/\partial E)(\partial q_j/\partial E) - (\partial q_i/\partial E)q_j \qquad i,j = 1, \ldots, n.$$

The three terms on the right in (A.8) are the specific substitution effect, the general substitution effect, and the income effect, respectively. The specific substitution effect (λu^{ij}) deals with the interaction of good i and j in the utility function where u^{ij} is the $(i, j)^{th}$ element of U^{-1}. The general substitution effect ($-\phi E(\partial q_i/\partial E)(\partial q_j/\partial E)$) is concerned with the competition of all n goods for an extra dollar of the total expenditure. The term ϕ is the income flexibility and the

reciprocal of this is the income elasticity, $\eta_i = 1/\phi = (\partial\lambda/\partial E)(E/\lambda)$. The last term $(-(\partial q_i/\partial E)q_j)$ is the income effect of the j^{th} price change on demand for the i^{th} good. These three terms can be used to obtain a demand equations in the differential form.

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BIOGRAPHICAL SKETCH

Pattana Aviphant Jierwiriyapant was born on December 24, 1957, in Chiangmai, Thailand. She received a Bachelor of Science degree in agronomy from Chiangmai University, Thailand, in 1981. Upon completion of her studies, she worked with the Consortium in Phanatnikhom for three years as a teacher. She then worked as an agricultural trainer with the Peace Corps in Thailand for one year. In 1985, she was awarded a Rotary International Scholarship to continue her education in the master's program in the Food and Resource Economics Department of the University of Florida. Her Master of Science degree was awarded in December, 1987. Upon graduation, she continued her graduate studies in the doctoral program in the same department. She is also a member of Gamma Sigma Delta, the honor society of Agriculture. Pattana is married to Udom Jierwiriyapant and has one daughter, Kemarin.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Jong-Ying Lee, Chairman
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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